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JSC-17433

VOL. II

A Joint Program for  
Agriculture and  
Resources Inventory  
Surveys Through  
Aerospace  
Remote Sensing

## Foreign Commodity Production Forecasting

September 29, 1981

### PRELIMINARY TECHNICAL RESULTS REVIEW OF FY81 EXPERIMENTS Volume II FISCAL YEAR 1981/1982 'CORN AND SOYBEANS PILOT' EXPERIMENT

(E82-10216) AGRI-STARS. PRELIMINARY  
TECHNICAL RESULTS REVIEW OF FY81  
EXPERIMENTS. VOLUME 2: FISCAL YEAR  
1981/1982 'CORN AND SOYBEANS PILOT'  
EXPERIMENT (NASA) 170 P EC AC8/MF A01  
Unclassified  
G3/43 00210  
N 82-23589  
March 3 1982



Lyndon B. Johnson Space Center  
Houston, Texas 77058

This report (Volume II of 2 Volumes) documents the Preliminary Technical Results Review (PTRR) for FY81. The review was held at the Lyndon B. Johnson Space Center on September 28 and 29, 1981. Volume I contains the results presented at the FY81/82 Spring Small Grains Pilot Experiment Review and Volume II contains the results presented at the FY81/82 Corn and Soybeans Experiment Review.

  
Jon D. Erickson  
FCPF Project Manager

FY81 PTRR AGENDA

FY81/82 CORN AND SOYBEANS PILOT EXPERIMENT

September 29, 1981

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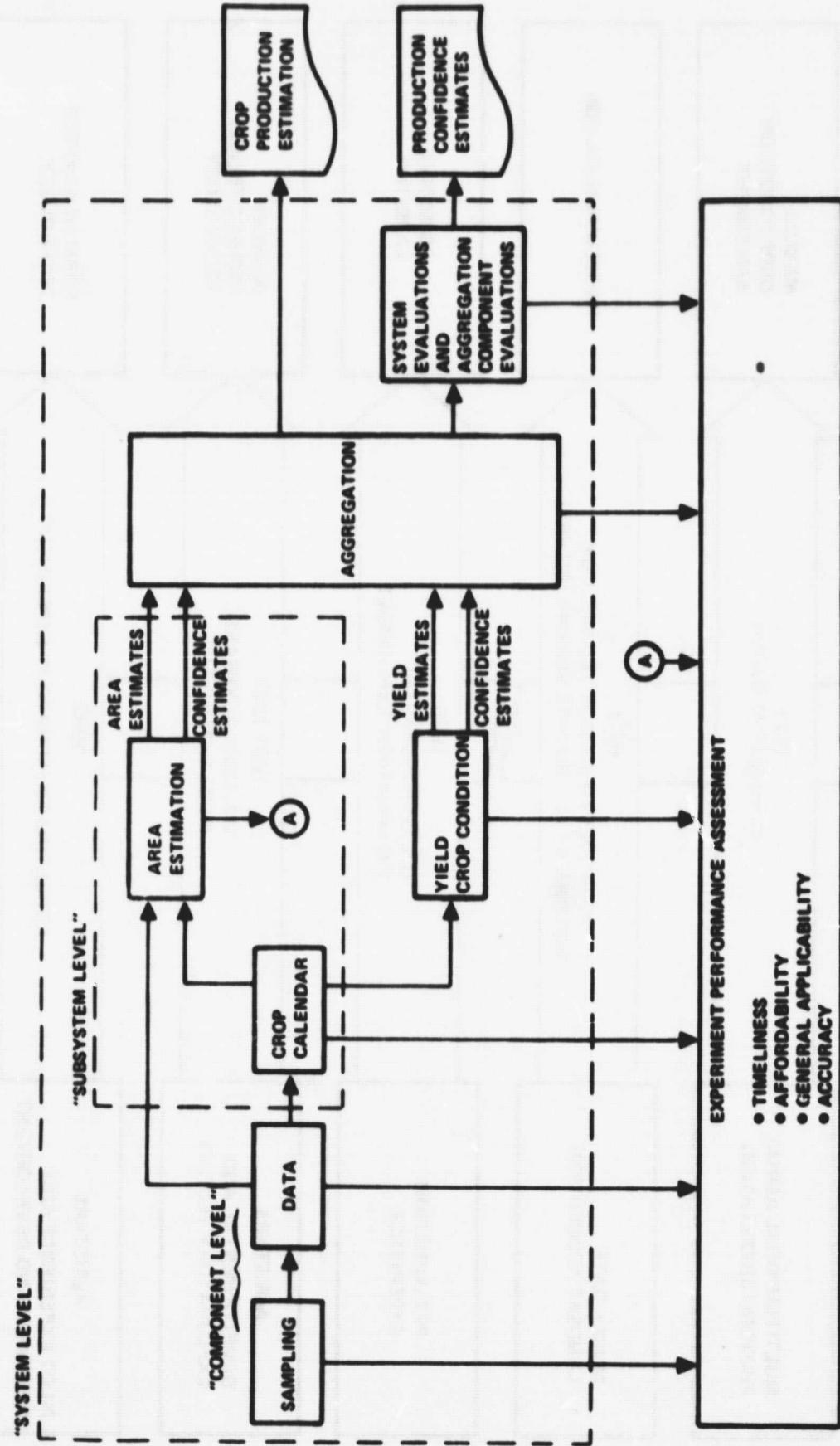
R. M. Bizzell  
September 29, 1981

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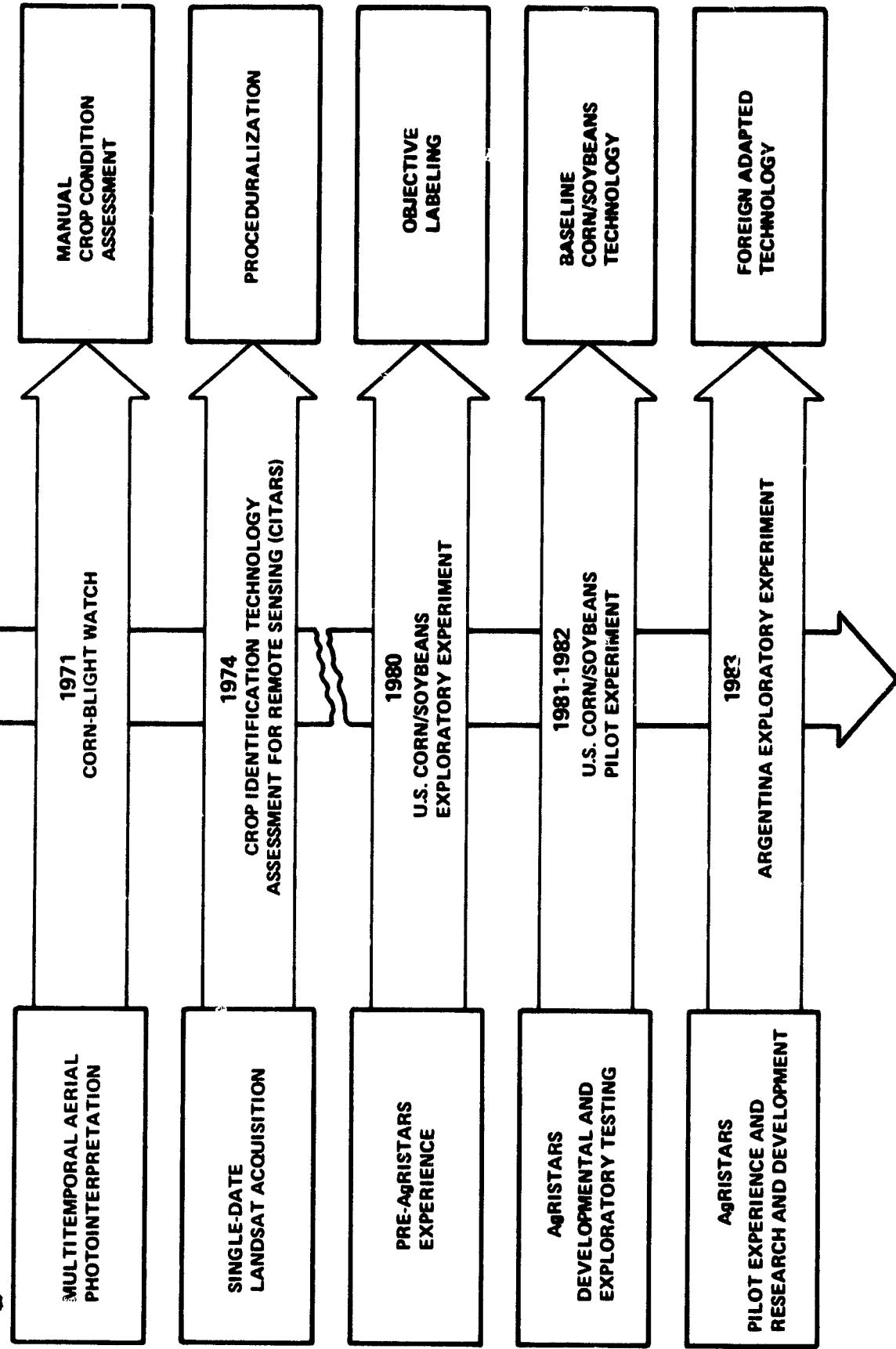
## 1.0 INTRODUCTION

NASA-S-81-11673

# FCPF APPLICATIONS AGRICULTURE INFORMATION SYSTEM CONCEPT



**BACKGROUND  
CORN/SOYBEAN TECHNOLOGY  
TIMELINE**



## FY80 EXPLORATORY

### ACCOMPLISHMENTS AND TECHNICAL CONCERNS

- THE FY80 EXPLORATORY WAS A LABELING EXPERIMENT.
  - + IT PROVIDED INITIAL ESTIMATES OF VARIANCE TO SUPPORT AGGREGATION RESEARCH.
  - THE PERFORMANCE OF THE TECHNOLOGY EXHIBITED SIGNIFICANT PROPORTION ESTIMATION ERRORS, SPECIFICALLY, HIGH MEAN ERRORS IN BOTH CORN AND SOYBEANS AREA ESTIMATION.
  - + IT REPRESENTED THE FIRST APPLICATION OF LABELING TO CORN AND SOYBEANS AND PRODUCED EXCELLENT LABELING ACCURACY ON PURE TARGETS.
  - + THE USE OF A HIERARCHICAL DECISION LOGIC ESTABLISHED A PROTOTYPE FOR OBJECTIVE MANUAL PROCEDURES.
  - ALTHOUGH THE CORN AND SOYBEANS LABELING PROCEDURE ESTABLISHED A PROTOTYPE FOR OBJECTIVITY, IT WAS ANALYST-INTENSIVE. THIS CAUSED TWO CONCERNS FOR FURTHER DEVELOPMENT:
- 1. ANALYST-INTENSIVE PROCEDURES REQUIRE SUBSTANTIAL AMOUNTS OF SUPPORTING PRODUCTS (E G., CROP CALENDARS, MAPS, SPECTRAL AIDS). PREPARATION AND USE OF THESE PRODUCTS REQUIRES EXTENSIVE LOGISTIC PLANNING AND IMPLEMENTATION.
- 2. ANALYST-INTENSIVE PROCEDURES ARE PRONE TO BE AFFECTED BY CLERICAL ERRORS, PROCEDURE MISINTERPRETATION, AND ANALYST-TO-ANALYST INCONSISTENCIES. AS A RESULT, ISOLATION OF SPECIFIC SUBCOMPONENT CONTRIBUTIONS TO PROPORTION ESTIMATION ERROR IS DIFFICULT.

TECHNICAL NEEDS IDENTIFIED

- ESTABLISH A CORN AND SOYBEANS BASELINE TECHNOLOGY WHICH ALLOWS SUB-COMPONENT DEVELOPMENT AND TESTING IN AN EXPERIMENTAL ENVIRONMENT.
- DEVISE A TECHNIQUE TO PROVIDE PURE TARGETS FOR ANALYST LABELING WHILE MAINTAINING THE HIGH ACCURACIES OBTAINED THROUGH PURE PIXEL LABELING.
- DEVELOP AND TEST AN APPROACH TO PROPORTION ESTIMATION WHICH ADDRESSES THE PROBLEMS CAUSED BY MIXED AND BOUNDARY PIXELS.
- DEVELOP AND TEST AN APPROACH TO IMPROVING LABELING ACCURACY ON TARGETS WITH CROP GROWTH PATTERNS WHICH DEVIATE FROM NORMAL.

GENERAL OBJECTIVES OF THE FY81/82 FCPF U.S. CORN/SOYBEANS PILOT EXPERIMENT

- TEST AND EVALUATE AN INTEGRATED TECHNOLOGY DESIGNED FOR AT-HARVEST AREA, YIELD, AND PRODUCTION ESTIMATES FOR CORN AND SOYBEANS IN THE U.S. CENTRAL CORN BELT.
- TEST AND EVALUATE EACH OF THE MAJOR COMPONENTS OF THE PRODUCTION SYSTEM: I.E., SAMPLING, CROP CALENDAR, AREA ESTIMATION, YIELD ESTIMATION, AND AREA AGGREGATION AND PRODUCTION.
- EVALUATE THE COMPONENTS AND SUBCOMPONENTS OF THE CORN/SOYBEAN (AT-HARVEST) AREA ESTIMATION SUBSYSTEM (C/S 1)
- TEST AND EVALUATE THE MULTICROP SAMPLING AND AGGREGATION PROCEDURES FOR CORN AND SOYBEANS TO OBTAIN FINAL PERFORMANCE ASSESSMENTS.
- IDENTIFY SUBSEQUENT REFINEMENTS/IMPROVEMENTS IN THE TECHNOLOGY FOR APPLICATION IN FOREIGN AREAS, PARTICULARLY ARGENTINA.

SPECIFIC OBJECTIVES OF THE FY81 CORN AND SOYBEANS EXPERIMENT

- ADAPT A CORN AND SOYBEAN PRODUCTION ESTIMATION TECHNOLOGY TO A NEW CROP REGION USING EXISTING AREA ESTIMATION SUBCOMPONENTS - E.G., LABELING AND PROPORTION ESTIMATION - AND A CONSORTIUM OF RESEARCH AND DEVELOPMENT INSTITUTIONS. IMPLEMENT THIS TECHNOLOGY, ADDRESSING THE TECHNICAL NEEDS IDENTIFIED IN THE FY80 EXPLORATORY, AS A BASELINE FOR THE DEVELOPMENT OF A TECHNOLOGY FOR FOREIGN APPLICATION.
- DEVELOP AND IMPLEMENT AN EXPERIMENTAL METHODOLOGY WHICH WILL TEST THIS TECHNOLOGY AND PROVIDE EVALUATION RESULTS TO BE INCORPORATED INTO FURTHER DEVELOPMENT.
- EVALUATE THE PERFORMANCE OF THE BASELINE TECHNOLOGY IN A CONTROLLED EXPERIMENTAL ENVIRONMENT TO IDENTIFY AND QUANTIFY THE SUBCOMPONENTS THAT CONTRIBUTE THE SIGNIFICANT PROPORTION OF ERROR TO THE SEGMENT PROPORTION ESTIMATE.

"TECHNICAL PROGRESS" CRITERIA  
TECHNOLOGY PERFORMANCE GOALS

- TIMELINESS
    - ESTIMATES DURING SEASDN
    - QUICK TURNAROUND (FROM EVENT TO ESTIMATE)
  - AFFORDABILITY
    - ⊕ EFFICIENCY
    - COST EFFECTIVENESS
  - GENERAL APPLICABILITY
    - APPLICABLE IN FOREIGN AREA (USES ONLY GLOBALLY AVAILABLE INPUTS)
    - ⊕ OBJECTIVITY
    - ⊕ GOOD PROCESSABILITY (CAPABLE OF PROCESSING LARGE PERCENTAGE OF ACQUISITIONS)
    - ⊕ FLEXIBLE, IMPROVABLE
    - ⊗ UNDERSTANDABLE TO USER
  - ACCURACY
    - ⊕ BIAS — PRECISION
    - ⊕ CONSISTENCE — RELIABILITY (OVER YEARS)
    - ⊕ RESPONSIVE "O "SIGNIFICANT" FACTORS (PARTICULARLY "DEPARTURES FROM AVERAGE")
- $\oplus$  Directly Addressed  
 $\otimes$  Partially Addressed  
 $\ominus$  Indirectly Addressed

ACCOMPLISHMENTS TO DATE

FY81/82 U.S. CORN AND SOYBEANS PILOT EXPERIMENT

- AN AREA ESTIMATION SUBSYSTEM HAS BEEN ADAPTED TO SERVE AS A BASELINE FOR DEVELOPMENT OF CORN AND SOYBEANS PRODUCTION ESTIMATION TECHNOLOGY.
- + THE SUBSYSTEM WAS DEVELOPED OUTSIDE OF JSC AND SUCCESSFULLY IMPLEMENTED AT JSC.

ACCOMPLISHMENTS TO DATE

FY81/82 U.S. CORN AND SOYBEANS PILOT

- AN EXPERIMENTAL METHODOLOGY FOR THE DEVELOPMENT, TESTING, EVALUATION, AND IMPROVEMENT OF GENERIC TECHNOLOGY HAS BEEN IMPLEMENTED AND APPLIED TO THE BASELINE CORN AND SOYBEANS AREA ESTIMATION PROCEDURE (CS1).
- + THE MECHANISM HAS BEEN DEVELOPED AND IMPLEMENTED BY A FORMAL CONSORTIUM OF ERIM, LEMSCO, AND UCB.
- + THE METHODOLOGY CONTAINS TWO DATA SYSTEMS:
  - DATA PROCESSING
  - ACCURACY ASSESSMENT
- + THE METHODOLOGY CONTAINS A STANDARDIZED PROCEDURE FOR EXPRESSING AND PROVISIONING DATA REQUIREMENTS.
- + THE METHODOLOGY CONTAINS ELEMENTS WHICH ALLOW USEFUL RESULTS TO BE INCORPORATED INTO THE DEVELOPMENT OF IMPROVED SUBSYSTEMS IN A TIMELY MANNER.

ACCOMPLISHMENTS TO DATE

FY81/82 U.S. CORN AND SOYBEANS PILOT

- APPLICATION OF THE EXPERIMENTAL METHODOLOGY TO THE BASELINE AREA ESTIMATION PROCEDURE PROVIDED INSIGHTS INTO THE PROCEDURE'S STRENGTHS AND WEAKNESSES. THESE INSIGHTS ALLOWED DEVELOPERS TO IMPLEMENT REFINEMENTS TO THE PROCEDURE, THUS UPGRADING THE TECHNOLOGY.

- ACCOMPLISHMENTS TO DATE
- FOREIGN APPLICATION OF CORN AND SOYBEANS TECHNOLOGY
- DEVELOPMENT REQUIRED FOR ADAPTION OF CORN AND SOYBEANS BASELINE TECHNOLOGY TO FOREIGN AREAS IS UNDERWAY.

## **2.0 THE U. S. CORN AND SOYBEANS PILOT EXPERIMENT**

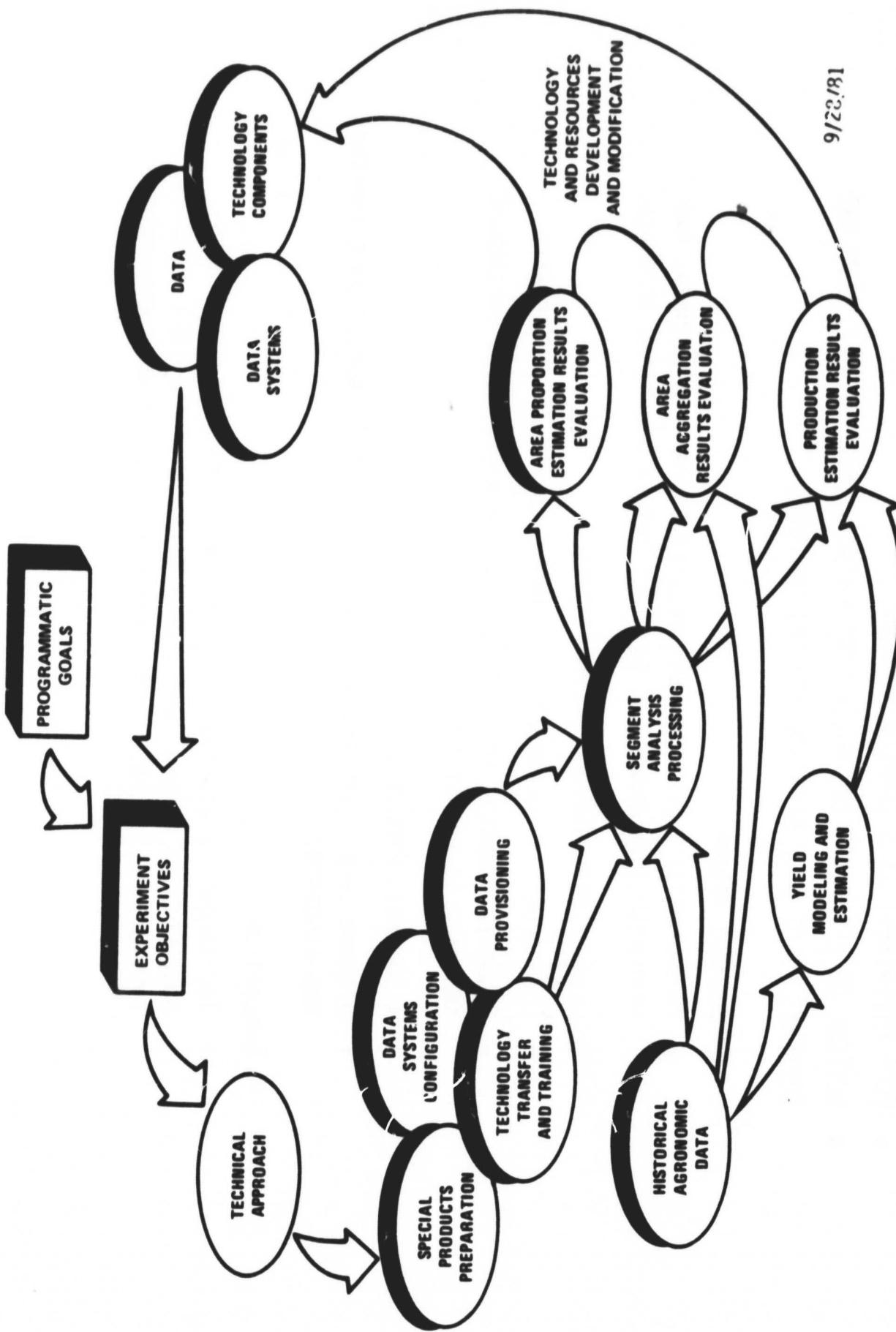
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R. W. PAYNE  
9/29/81

2.1

## EXPERIMENT OVERVIEW

## FCPF EXPERIMENTAL METHODOLOGY



## FCPF EXPERIMENTAL METHODOLOGY

- FCPF EXPERIMENT IS A COMPLEX PROCESS.
- SEVERAL OF THE FUNCTIONS WHICH MUST EXIST WITHIN THE U.S. CORN AND SOYBEANS PILOT HAVE BEEN IMPLEMENTED IN FY81.
  - EXPERIMENT DESIGN
    - + PROGRAMMATIC AND EXPERIMENT OBJECTIVES, AVAILABLE DATA, AND AVAILABLE TECHNOLOGY ARE COMBINED INTO A TECHNICAL APPROACH.
  - EXPERIMENT PREPARATION/IMPLEMENTATION
    - + TECHNOLOGY IS DELIVERED AND CONFIGURED; TRAINING OCCURRED.
    - + REQUIRED PRODUCTS ARE PREPARED (CLIMAGRAPHS, CROP CALENDARS) AND DATA IS PROVISIONED.
  - DATA ANALYSIS/PROCESSING
    - + SEGMENT-LEVEL CORN AND SOYBEANS AND "OTHER" PROPORTION ESTIMATES ARE GENERATED.
  - EVALUATION
    - + TECHNOLOGY IS ASSESSED AT SUBSYSTEM (AREA ESTIMATION) AND SUBCOMPONENT LEVELS (E.G., CROP CALENDAR, LABELING). RESULTS PROVIDED TO TECHNOLOGY DEVELOPERS AND TO PROJECT MANAGEMENT.

FCPF EXPERIMENT METHODOLOGY (CONTINUED)

- THE REMAINING FUNCTIONS IN THE U.S. CORN AND SOYBEANS PILOT EXPERIMENT ARE SCHEDULED TO BE IMPLEMENTED IN FY82.
  - 1980 DATA ANALYSIS/PROCESSING
  - AREA AGGREGATION (3-STATE: U.S. CENTRAL CORN BELT)
  - PRODUCTION ESTIMATION

## FY81

- NOVEMBER 1980
  - 1980 DATA NOT EXPECTED TO BE AVAILABLE TO SUPPORT THIS EXPERIMENT.
    - + IMPLEMENTED PHASED APPROACH
      - PHASE I - 1978/1979 DATA; IN-DEPTH SUBCOMPONENT STUDY
      - PHASE II - 1978/1979 DATA; SUBCOMPONENT STUDY/UPDATE
        - 1980 DATA; DEMONSTRATE REGIONAL AREA ESTIMATION
    - + PHASE I IMPLEMENTED
- JANUARY 1981
  - PRELIMINARY DESIGN REVIEW (PDR), PHASE I
- FEBRUARY 1981
  - 1980 DATA AVAILABILITY EXPECTED JUNE 1
    - + RESCOPED EXPERIMENT DESIGN TO INCLUDE 1980 DATA EVALUATIONS IN FY82
- APRIL 1981
  - MODIFIED FY81 BUDGET
- SEPTEMBER 1981
  - PRELIMINARY RESULTS OF 1978/1979 DATA PROCESSING AND EVALUATIONS
    - + RESCHEDULED INITIATION OF 1980 DATA PROCESSING (FROM JULY TO OCTOBER 1981)
    - + PROCEDURE MODIFICATIONS DEVELOPMENT INITIATED
    - + PLANNED TO ADDRESS ALTERNATIVE PROCEDURES WITHIN U.S. PILOT IN FY82
  - PRELIMINARY RESULTS OF 1978/1979 DATA PROCESSING AND EVALUATIONS
    - + PTRR

# **DATA SYSTEMS**

2.6

M. METZLER  
9/29/81

**FCPP DATA SYSTEMS  
APPLICATIONS TO CORN AND SOYBEANS TECHNOLOGY**

- THE FCPP DATA SYSTEMS HAVE BEEN APPLIED TO THE CORN AND SOYBEANS TECHNOLOGY AT TWO LEVELS:
  1. GENERIC -- SUPPORTING TECHNOLOGY DEVELOPMENT (STARS)
  2. EXPERIMENT SPECIFIC -- SUBSYSTEMS SUPPORTING THE U.S. CORN AND SOYBEANS PILOT (CSI PROCESSING AND PERFORMANCE EVALUATION)

## **SOFTWARE TECHNOLOGY FOR AEROSPACE REMOTE SENSING (STARS)**

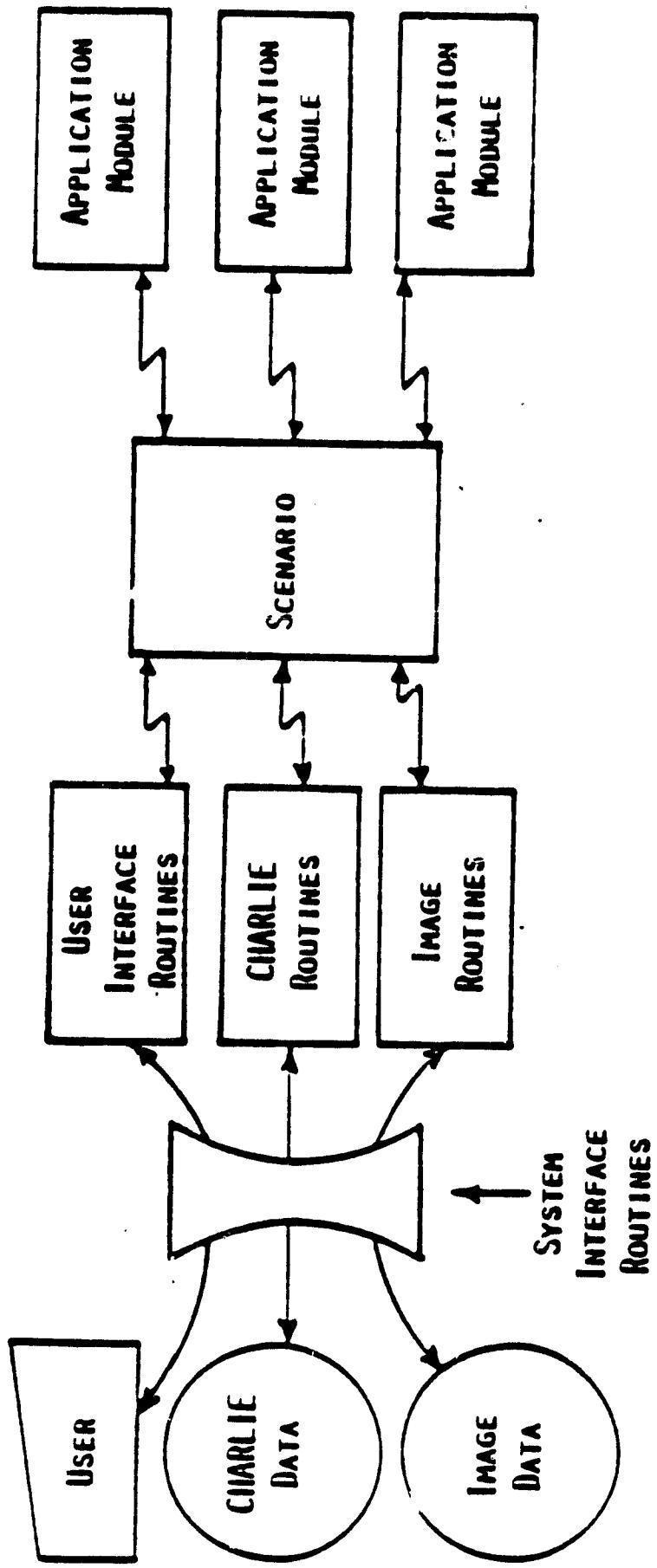
- A Software System Developed for Large Scale Configuration Controlled Processing and for Research and Development
- Provides User (Programmer or Applications) an Environment that is Largely Data and System Independent, Providing Services for the Storage and Retrieval of Data
- Provides the Experiment Manager with Utilities to Permit Status and Tracking, and Control of Experiment Operations Including Tape and Disk Management and Processing Flow Control

## SOFTWARE TECHNOLOGY FOR AEROSPACE REMOTE SENSING (STARS)

### KEY DESIGN ELEMENTS

- Simple High Level User Interface
  - Data Independence
  - Command language driven
- Status and Tracking
  - Event log
  - Management query capability
- Efficient Single Function Application Modules
  - Data Independence
  - Assembly line raster processing
- Data Management Services
  - CHARLIE (collateral holding and reference library for information extraction)
  - Image management routines
- Operating System Independence
  - Transportable application modules
  - Multiple system implementation

## SYSTEM ORGANIZATION



## STARS APPLICATIONS

### EXISTING

- Available on 3 Computers and 2 Different Operating Systems
- U.S. C/S Baseline Procedure (C/S-1)
- Modified Baseline Procedure (C/S-1A)
- Crist Profile Matching SSG and W/B Procedure (SR)
- Additional Research Capabilities (GT Processor, Mapping, etc.)
- Configuration Control Processors (e.g., ASK)

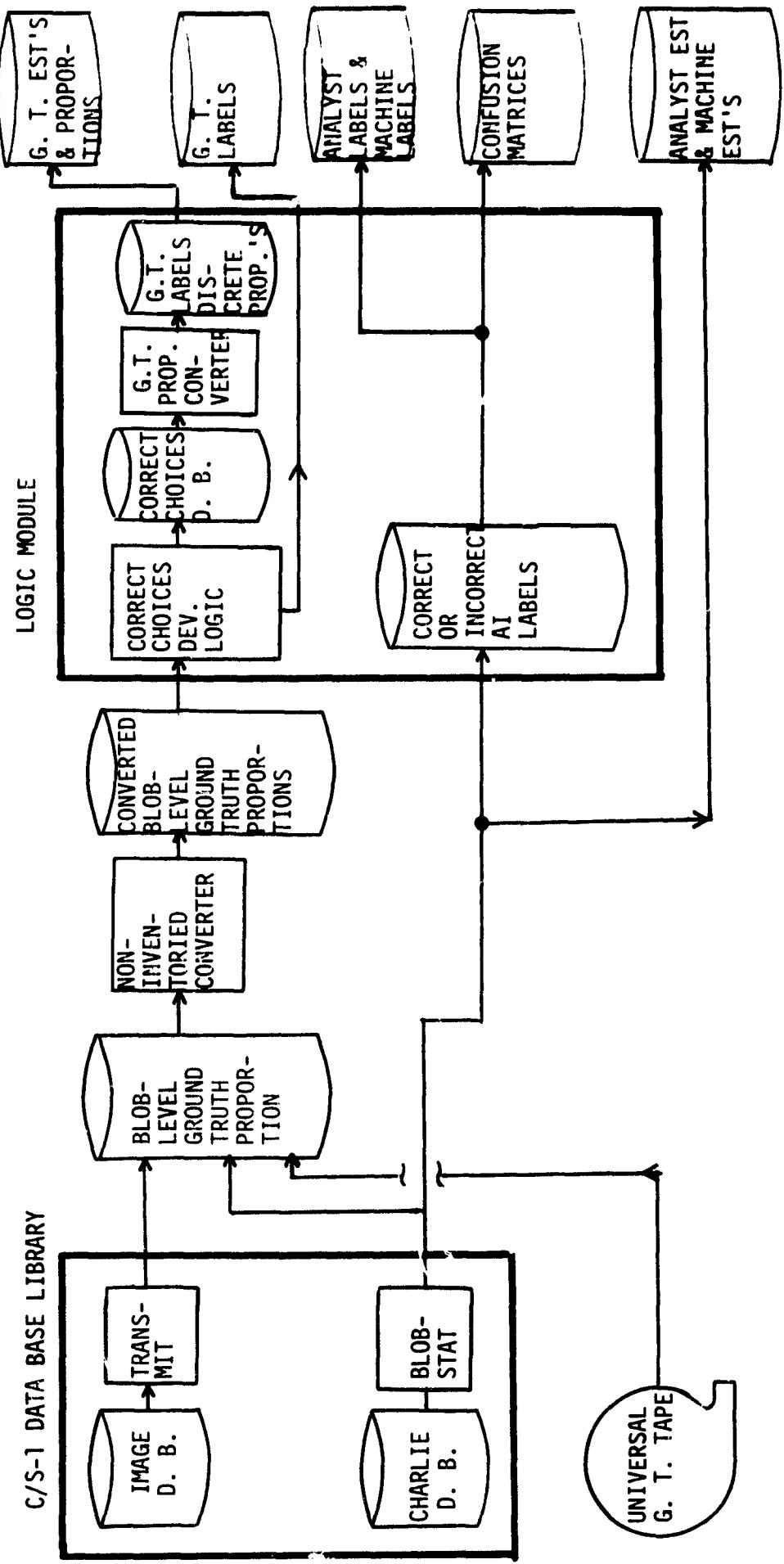
### IN DEVELOPMENT

- Automatic Early Season Profile Matching (C/S-5)
- Wade Objective C/S Labeler with Relocated Dots (C/S-2A)

## DATA SYSTEMS

- SYSTEMS SUPPORTING THE U.S. CORN AND SOYBEANS PILOT EXPERIMENT
- CS1 -- PROPORTION ESTIMATION/AREA ESTIMATION COMPONENT — DEVELOPED UNDER STARS
- PERFORMANCE EVALUATION: "SYSTEM" (CS1) -- DEVELOPED BY LEMSCO WITH MODULES FROM CS1, ERIM AND LEMSCO
- MAIN FEATURES AND TECHNICAL ACCOMPLISHMENTS RELATED TO CS1 AND THE EVALUATION "SYSTEM"
  - + THE EXPERIMENTAL SYSTEMS WERE DESIGNED IN A MODULAR FORMAT.
    - ALL SYSTEMS USING COMMON COMPONENTS
    - FACILITATES TESTING OF COMPONENTS AND POSSIBLE ALTERNATES
    - PROVIDES THE MECHANISM FOR ESTIMATING, IN ADDITION TO PERFORMANCE: TIMELINESS, COST EFFECTIVENESS, AFFORDABILITY, ETC.
    - PROVIDES "BUILDING BLOCKS" FOR CONSTRUCTING NEW SYSTEMS FROM RECENT DEVELOPMENTS AND OPTIMAL COMPONENTS
  - + DURING THE DEVELOPMENT AND APPLICATION OF THESE SYSTEMS, DATA BASES WERE DEVELOPED AND MAINTAINED BY FCPF. THESE DATA BASES SUPPORT —
    - CURRENT AND FUTURE EXPERIMENTS
    - TECHNIQUES DEVELOPMENT
    - LONG-TERM EVALUATION AND TESTING IN EXPERIMENTS
  - + METHODS TO CHANGE THE SYSTEMS' CONFIGURATION WERE SUCCESSFULLY TESTED. THESE PROCEDURES, AND THE INTEGRATION AND COORDINATION OF MODULES AND DATA BASES WITHIN AND BETWEEN SYSTEMS MAINTAINED EXPERIMENT INTEGRITY AND INSURED RELIABLE RESULTS.

CSIA PERFORMANCE EVALUATION SUBSYSTEM



D. T. REGISTER  
9/29/81

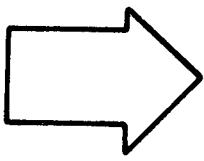
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## TECHNICAL APPROACH

## SEGMENT-LEVEL AREA ESTIMATION

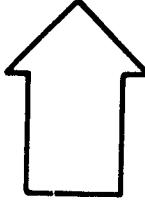
### PROCEDURE DEFICIENCIES:

- LABELING
- TARGET SAMPLING
- ESTIMATION
- BIOWINDOW DESIGNATION
- REGISTRATION

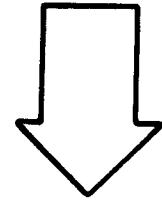


### METEOROLOGY:

- RAINFALL AND TEMPERATURE PATTERNS
- LOCATION OF METEOROLOGICAL STATIONS

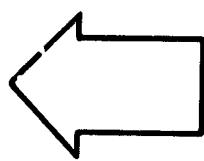


# ERROR



### LANDSAT DATA COLLECTION:

- AMOUNT
- TIMING
- RESOLUTION
- QUALITY



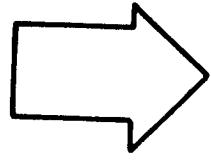
### AGRONOMY:

- CROP MIXTURE
- FIELD SIZE
- IRRIGATION
- FARMING PRACTICES

## LARGE AREA ESTIMATION

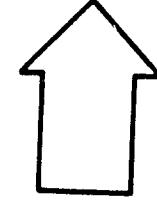
### PROCEDURE DEFICIENCIES

- INADEQUATE USE OF HISTORICAL GOVERNMENT STATISTICS
- INADEQUATE ALLOWANCE FOR MISSING DATA
- INADEQUATE USE OF PREVIOUS YEARS PROPORTION ESTIMATES



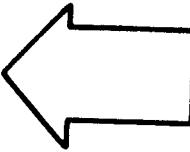
### SAMPLE DEFICIENCIES:

- SAMPLING FRAME
- STRATA DELINEATION
- ALLOCATION METHOD
- SAMPLE SIZE
- CHANCE



### SEGMENT-LEVEL ESTIMATES:

- PROPORTION ESTIMATION ERROR
- MISSING PROPORTION ESTIMATES
- CROP GROUP PROPORTION ESTIMATES



### HISTORICAL GOVERNMENT STATISTICS:

- SPARSE
- INACCURATE

AREA ESTIMATION EVALUATIONS

FY1981:

EVALUATION

PURPOSE

PROPORTION ESTIMATION EFFICIENCY

IDENTIFY SUBCOMPONENTS FOR DEVELOPMENT  
TOWARDS IMPROVED EFFICIENCY.

RATE OF PROCESSABILITY

VALIDATE THE BASELINE PROCEDURE'S  
SUITABILITY TO SUPPORT AN AGGREGATION  
EXPERIMENT.

## AREA ESTIMATION EVALUATIONS

FY1981:

<u>EVALUATION</u>	<u>PURPOSE</u>
PROPORTION ESTIMATION EFFICIENCY	IDENTIFY SUBCOMPONENTS FOR DEVELOPMENT TOWARDS IMPROVED EFFICIENCY.
RATE OF PROCESSABILITY	VALIDATE THE BASELINE PROCEDURE'S SUITABILITY TO SUPPORT AN AGGREGATION EXPERIMENT.
PROPORTION ESTIMATION ACCURACIES OF C/S-1 IN CROP YEARS 1978 AND 1979	VALIDATE THE BASELINE PROCEDURE'S SUITABILITY FOR USE IN A DEMONSTRATION EXPERIMENT (CROP YEAR 1980 DATA).
	DETERMINE ROBUSTNESS OF PERFORMANCE IN CROP YEARS DIFFERING IN METEOROLOGICAL CONDITIONS AND ACQUISITION HISTORIES.

## EVALUATION

### PURPOSE

EFFECT OF DIFFERENT TARGET LABELING SOURCES

DETERMINE THE ANALYST CONTRIBUTION TO PROPORTION ESTIMATION ACCURACY:

- (A) ACHIEVED BY USING ANALYST TARGET LABELS RATHER THAN THE PRELIMINARILY ASSIGNED MACHINE LABELS.
- (B) RELATIVE TO GROUND TRUTH LABELING OF TARGETS.

VALIDATE THE PROPORTION ESTIMATION APPROACH IN THE BASELINE PROCEDURE.

EFFECT OF TREATMENT OF UNSAMPLED PORTION OF THE SCENE

DETERMINE HOW WELL THE PROPORTION ESTIMATION PROCEDURE ACCOUNTS FOR THE UNSAMPLED PORTION OF THE SCENE.

EFFECT OF ANALYST TEAMS

DETERMINE REPEATABILITY IN THE EXECUTION AND PERFORMANCE OF THE BASELINE PROCEDURE BETWEEN ANALYST TEAMS.

ANALYST LABELING PERFORMANCE

GAIN UNDERSTANDING OF A MAJOR SUBCOMPONENT: ANALYST LABELING OF PROCEDURE GENERATED FIELDS (BLOBS).

RELATIONSHIP BETWEEN LABELING TARGET SIZE AND PROPORTION ESTIMATION ERROR

DETERMINE WHETHER THE ACCURACIES OF CORN AND SOYBEANS PROPORTION ESTIMATES ARE A FUNCTION OF TARGET SIZE.

## AREA ESTIMATION EVALUATIONS

FY1982:

### EVALUATION

PERFORMANCE ACCURACIES OF SUBCOMPONENTS  
WITHIN THE BASELINE PROCEDURE :

### DETERMINATION OF SPECTRAL BIOWINDOWS

GAIN AN UNDERSTANDING OF THE EMPIRICAL  
RELATIONSHIP BETWEEN THE ACCURACY OF  
BIOWINDOW DEFINITION AND THE ACCURACIES  
OF TARGET LABELS AND PROPORTION ESTIMATES.

### SPECTRAL/TEMPORAL STRATIFICATION OF CROP GROUPS

GAIN AN UNDERSTANDING OF THE FACTORS AFFECTING  
THE ACCURACY WITH WHICH PIXELS ARE STRATIFIED  
INTO CROP GROUPS.

### SPECTRAL SEPARATION OF CORN AND SOYBEANS

THIS IS THE BASIS FOR THE PRELIMINARY  
MACHINE ASSIGNMENT OF LABELS TO TARGETS.

### CONTRIBUTIONS TO BIAS IN THE STRATIFIED AREA PROPORTION ESTIMATES

GAIN UNDERSTANDING OF THE CONTRIBUTIONS TO  
BIAS FROM VARIOUS FACTORS INHERENT IN THE  
PROPORTION ESTIMATION PROCEDURE.

EVALUATION

CONTRIBUTIONS TO VARIANCE IN THE  
STRATIFIED AREA PROPORTION ESTIMATES

ASSESS THE POSSIBILITY OF REDUCING THE  
NUMBER OF LABELING TARGETS REQUIRED TO  
PRODUCE ACCEPTABLE AREA PROPORTION ESTIMATES.

PURPOSE

AREA AGGREGATION

FY1982:

TBD

# **DATA ASSESSMENT**

2.22

G. P. LIVINGSTON  
9/29/81

TEST NO.	TEST TYPE	CROP PROCEDURE/NAME	PROC. TYPE	TEST LEVEL	TEST REGION	SEGS.	YEAR(S)	DATE	TEST PERIOD
		U.S. CORN/SOYBEANS		U.S.				FROM	TO
7	PILOT	BASELINE PROCEDURE C/S-1	AREA ESTIMATION	SUBSYSTEM CENTRAL CORN BELT	28	78-79	9/28/ 81	10/80	10/81

#### DATA ASSESSMENT

##### FY78 - 979 U.S. MULTICROP DATA

###### O PURPOSE OF ALLOCATION

- DEVELOPMENT AND EVALUATION OF TECHNOLOGIES FOR CLASSIFICATION OF CORN AND SOYBEANS IN THE U.S.

###### O ALLOCATION

- NON-RANDOM

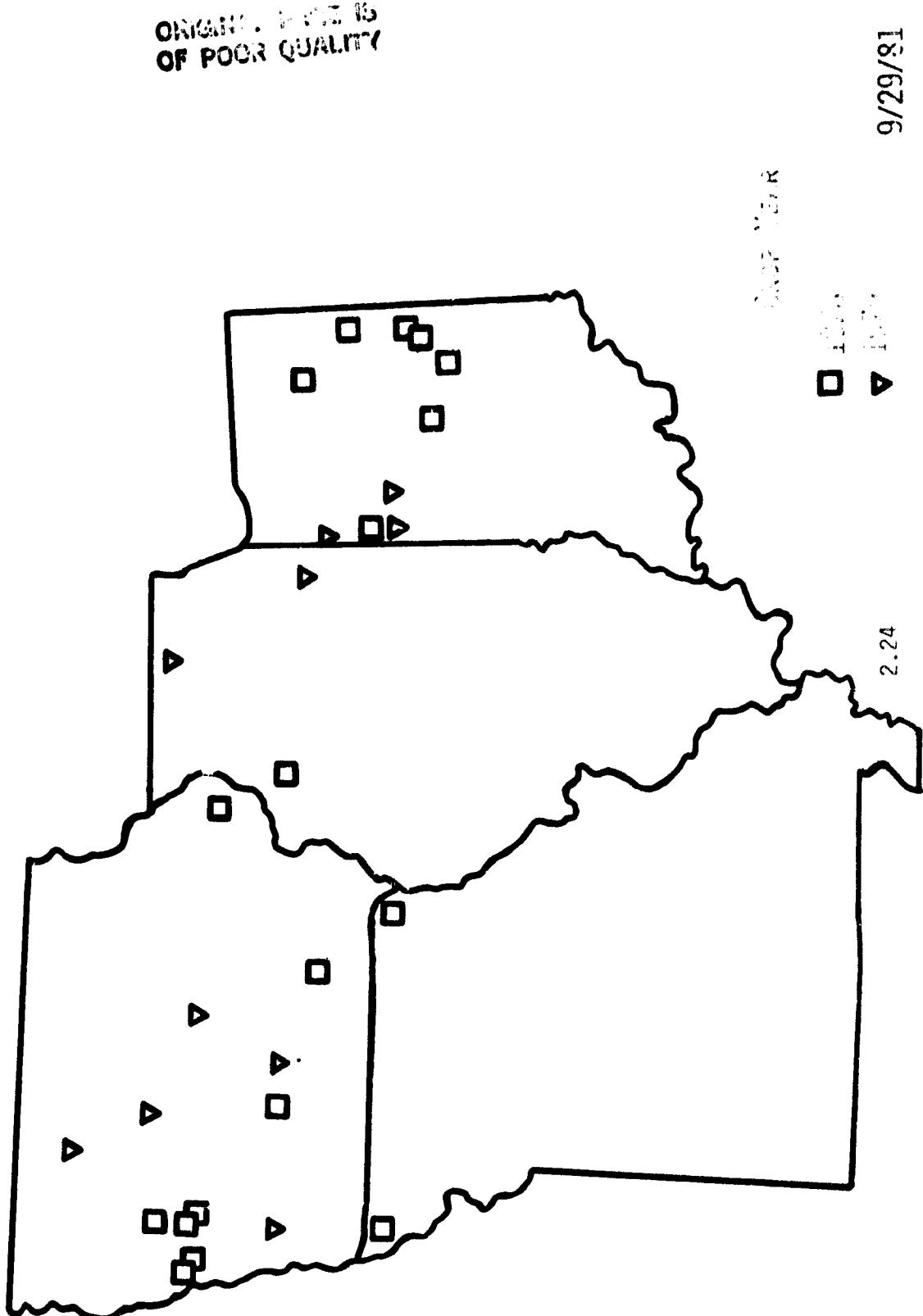
- BASED UPON NORMALIZED PRODUCTION OF CORN, SOYBEANS, AND AVERAGE FARM SIZE

###### O DEFINITION OF EXPERIMENT CANDIDATE DATA

- 1978/1979 SEGMENTS FROM THE U.S. CENTRAL CORN BELT WITH DIGITIZED GROUND TRUTH AVAILABLE
- SEGMENTS USED IN PROCEDURE DEVELOPMENT WERE EXCLUDED
- 13 CROP YEAR 1978 SEGMENTS PREVIOUSLY PROCESSED IN THE TY EXPLORATORY EXPERIMENT
- 12 SEGMENTS WITH LANDSAT ACQUISITION DATA AVAILABLE IN BOTH CROP YEARS 1978 AND 1979.

TEST NO.	TEST TYPE	CROP PROCEDURE NAME	PRCC. TYPE	TEST LEVEL	TEST REGION	SEGS.	YEAR(S)	DATE	TEST PERIOD
7	PILOT	U.S. CORN/SOYBEANS BASELINE PROCEDURE C/S-1		U.S. SUBSYSTEM	CENTRAL CORN BELT	28	78-79 9/29/81	10/80	10/81

LOCATION OF SEGMENTS WITHIN THE U.S. CENTRAL CORN BELT



9/29/81

O DATA ASSESSMENT (CONTINUED)

O NUMBER AND LOCATION OF SEGMENTS PROCESSED

CROP YEAR	INDIANA	ILLINOIS	IOWA	MISSOURI	TOTAL
1978	7	1	8	2	18
1979	3	2	5	0	10

O CHARACTERISTICS OF THE EXPERIMENT DATA

- ACQUISITION HISTORIES

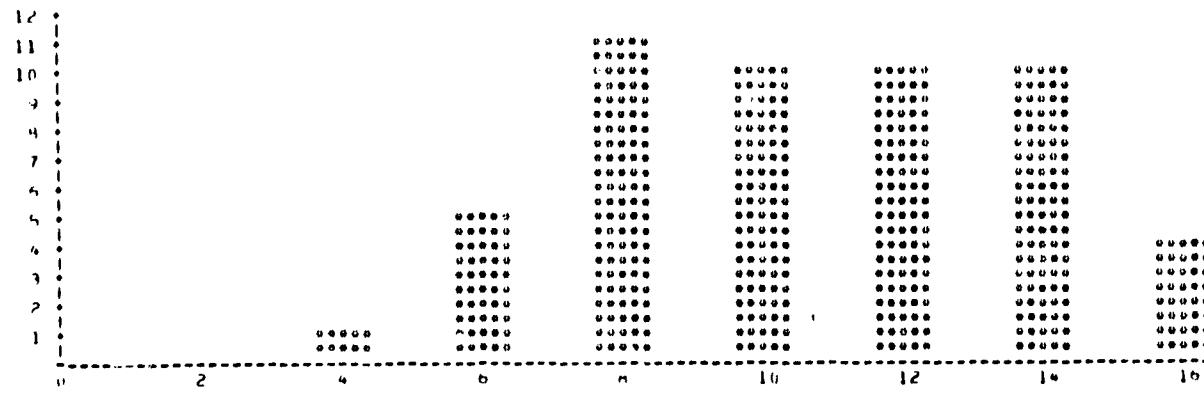
- + 9-DAY ACQUISITION HISTORIES (LANDSAT 2 & 3) AVAILABLE FOR BOTH CROP YEARS.
- + EXPERIMENT DESIGN SPECIFIED USE OF ONLY LANDSAT 2 DATA (18-DAY COVERAGE) IN THE 1979 CROP YEAR EVALUATIONS.

9/29/81

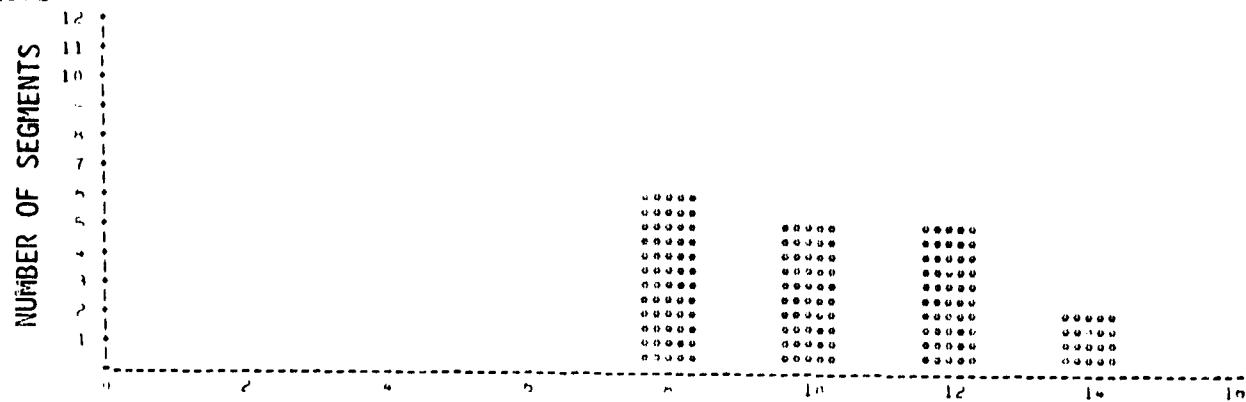
OPTIONAL FORM 10  
OF POOR QUALITY

FREQUENCY OF THE NUMBER OF LANDSAT  
ACQUISITIONS AVAILABLE  
WITHIN THE CENTRAL U.S. CORN BELT  
(CONSECUTIVE-DAY PAIRS COUNTED ONCE)

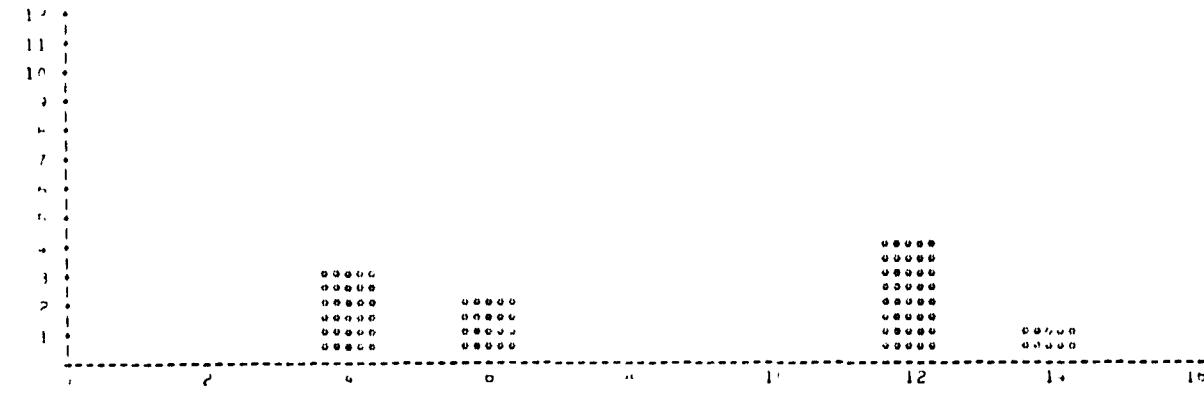
U.S. CENTRAL CORN BELT  
1978 UGTT SEGMENTS



1978 U.S. CORN/SOYBEANS PILOT EXPERIMENT



1979



NUMBER OF ACQUISITIONS

2.26

## DATA ASSESSMENT (CONTINUED)

### O CHARACTERISTICS OF THE EXPERIMENT DATA (CONTINUED)

#### - CROPPING PRACTICES

##### + PLANTING

1978 - DELAYED PLANTING OF SUMMER CROPS FROM 1-2 WEEKS DUE TO WET AND COOL METEOROLOGICAL CONDITIONS

1979 - INITIAL DELAY OF PLANTING ACTIVITIES FOR SUMMER CROPS ALTHOUGH LATER CONDITIONS PERMITTED NORMAL OR EARLY COMPLETION

##### + HARVESTING

###### CORN

1978 - HARVESTING OF CORN 1-3 WEEKS EARLIER THAN AVERAGE

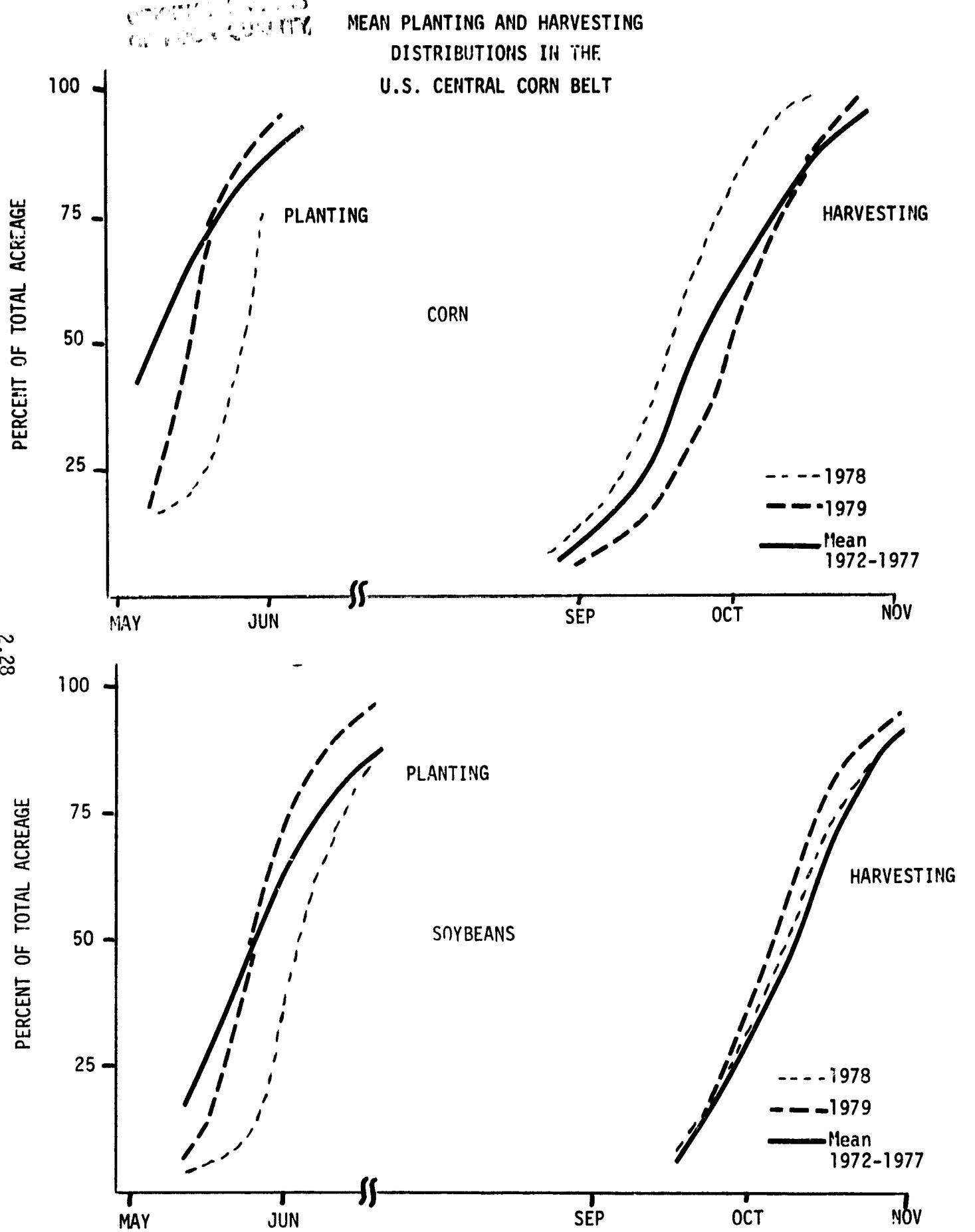
1979 - CORN HARVESTING NEAR NORMAL TO 1 WEEK LATER THAN AVERAGE

O CORN HARVESTING TIMES BETWEEN THE TWO CROP YEARS SUBSTANTIALLY DIFFERENT

###### SOYBEANS

- HARVESTING IN GENERAL NEAR NORMAL FOR BOTH CROP YEARS 1978 AND 1979

9/29/81



9/29/81

## DATA ASSESSMENT (CONTINUED)

- o CHARACTERISTICS OF THE EXPERIMENT DATA (CONTINUED)
  - CROP PROPORTIONS
    - + SUMMER CROP PROPORTIONS IN THE EXPERIMENT DATA SET WERE REPRESENTATIVE OF THE U.S. CORN BELT.
    - + APPROXIMATE 1% INCREASE IN SUMMER CROPS ACREAGES IN 1979 ON SEGMENTS PAIRED OVER YEARS.

### GROUND TRUTH PROPORTIONS (%)

	1978 N=18	1979 N=10
CORN	36.9	11.9
SOYBEANS	26.8	11.6
SUMMER CROPS	63.8	12.8
	$\bar{x}$	$\bar{x}$
	s	s

9/29/81

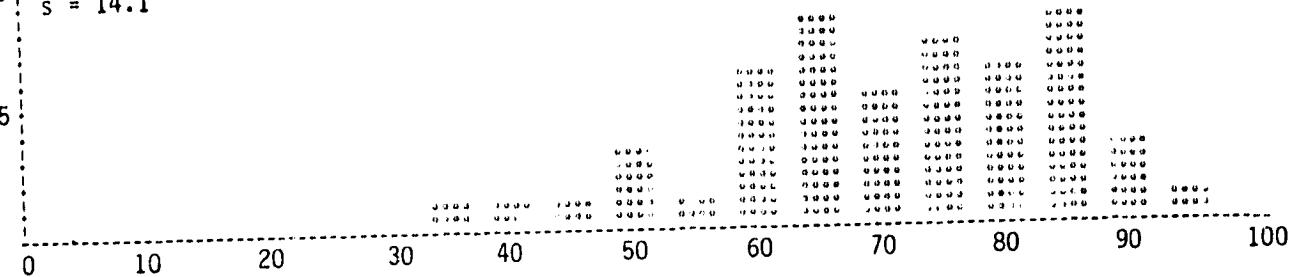
2.29

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FREQUENCY OF OCCURRENCE OF CROP GROUND TRUTH  
PROPORTIONS WITHIN THE U.S. CENTRAL CORN BELT  
1978

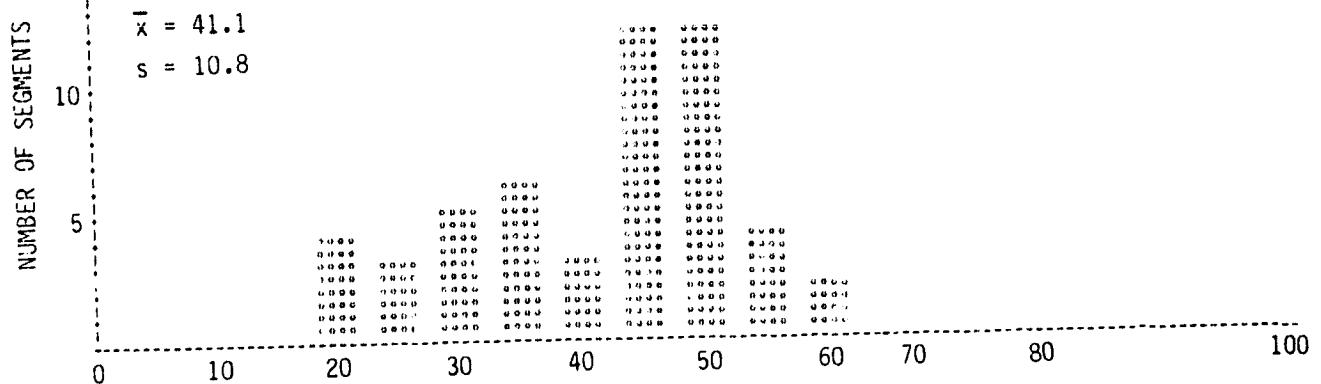
15: SUMMER CROPS

$n = 51$   
 $\bar{x} = 70.9$   
 $s = 14.1$



15: CORN

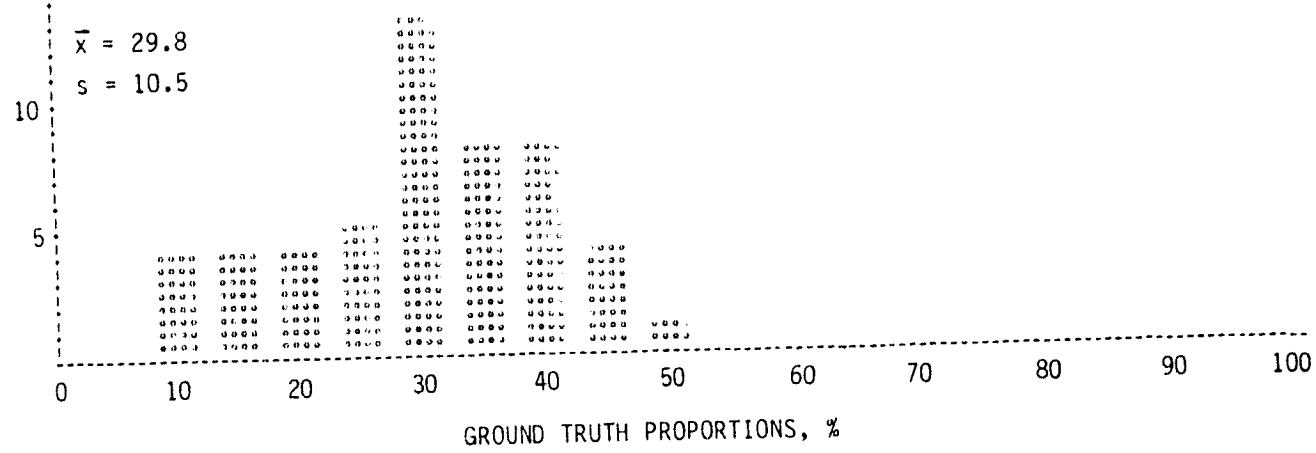
$\bar{x} = 41.1$   
 $s = 10.8$



2.30

15: SOYBEANS

$\bar{x} = 29.8$   
 $s = 10.5$



DATA ASSESSMENT (CONCLUDED)

O CHARACTERISTICS OF THE EXPERIMENT DATA (CONCLUDED)

- CONFUSION CROPS
  - + THE U.S. CENTRAL CORN BELT IS NEARLY FREE OF "CROPS" WITH SPECTRAL/TEMPORAL SIGNATURES COMPARABLE TO SUMMER CROP SIGNATURES.
  - + SORGHUM
- 1973 - 3 SEGMENTS IN 1973 WITH GROUND TRUTH PROPORTIONS > 0.6%
- RANGE 0 - 1.36%

1979 - NONE REPORTED IN ANY OF THE SEGMENTS PROCESSED.

9/29/81

2.31

**3.0**

**RESULTS TO DATE**

**3.0**

**DESCRIPTION OF U. S. CORN AND SOYBEANS  
BASELINE PROCEDURE (CSI)**

M. METZLER  
9/29/81

## C/S-1 BASELINE PROCEDURE

### SCOPE

- Integrate Current Technology Borne Out of LACIE and LACIE Transition into an End-to-End Corn and Soybean Segment Classification Procedure for Area Estimation, Addressing Technical Needs Highlighted by FY80 Exploratory: Labeling of Pures, Objective Labeling, Handling of Mixtures
- Design a Production System Operational Procedure so that the Influence of Each Component is Trackable
- Designed to be a Baseline from Which to Develop Improved Component Technologies and to Judge the Incremental Effects of Those Improvements
- The End Goal is to Evaluate the Potential of an Integrated Analyst Labeling/Machine Processing Procedure and its Components in Terms of Accuracy and Efficiency, While Maintaining Current Level of Accuracy

## GENEALOGY

- Integrated Analyst/Machine Area Estimation Procedure Based on a Combination of Earlier Technology
  - LEMSCO Corn/Soybean Procedure
  - UCB C/S Labeling Guidelines
  - UCB Delta Function Stratifier (DFS)
  - ERIM Procedure M
    - Data Normalization
    - Tasseled Cap Transformation
    - Quasi-field Labeling Targets
    - Modular Construction

## DEFINITIONS

CROP CALENDAR - historical dates of crop phenological stage development

BIOWINDOW - time period during which crops are at a certain stage of phenological/spectral development

ACQUISITION SELECTION - process of selecting acquisitions for TPC, BLOB, and C/S discrimination

GRABS - Greenness Above Bare Soil - measure of spectral emergence

TPC - Temporal Pattern Class - temporal spectral detectability

DFS - Delta Function Stratifier - crop group stratification based on expected crop growth patterns (TPCs)

C/S LINEAR DISCRIMINANT - line separating the spectral distribution of corn from that of soybeans

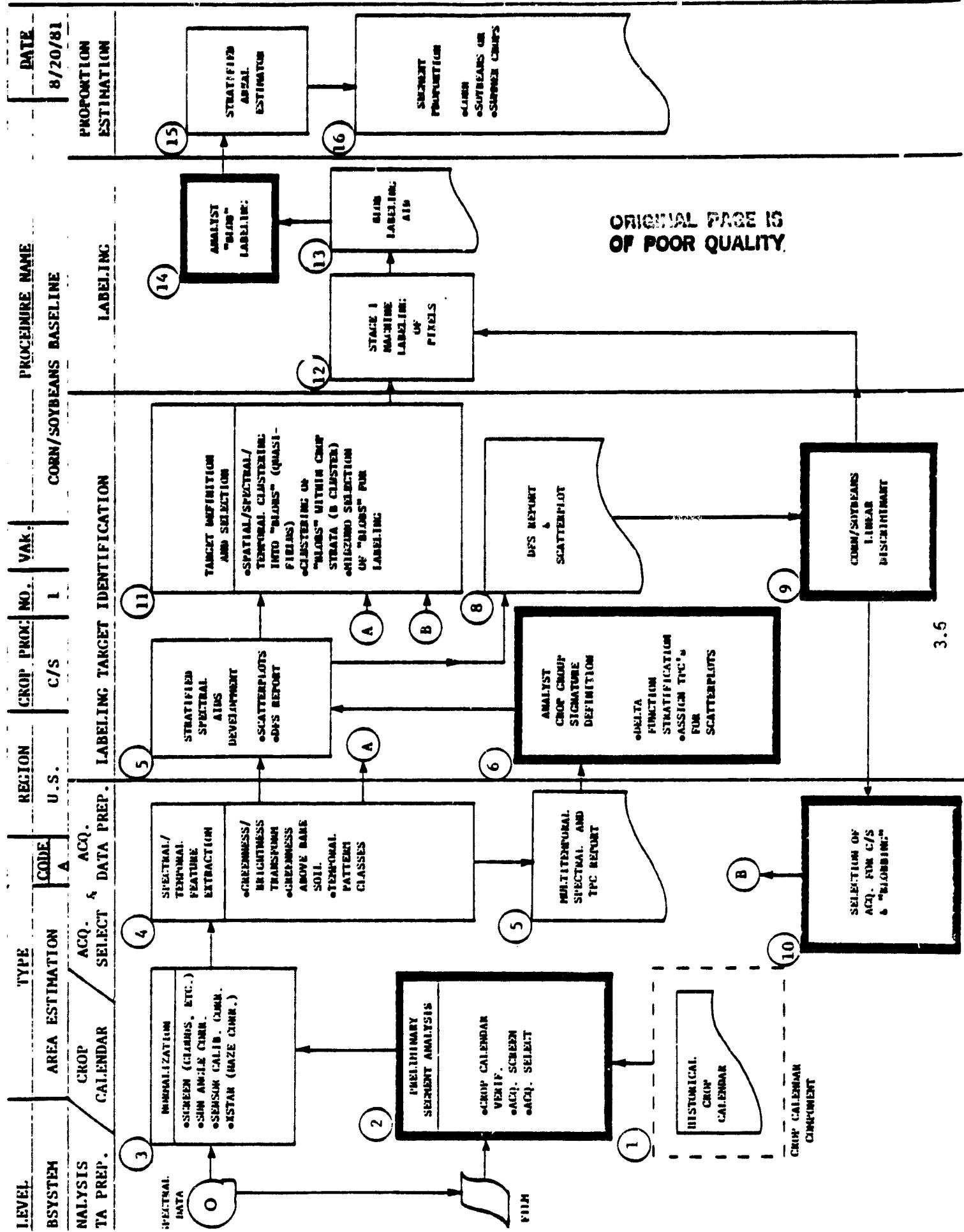
BLOB - field-like group-of spectrally similar/spatially contiguous pixels

BIG BLOB - blob in which more than 1 pixel is left in the interior when a 1 pixel boundary has been stripped off

LITTLE BLOB - blob with no interior pixels

**DEFINITIONS (Continued)**

- CLUSTER** - group of spectrally similar blobs
- MACHINE LABEL** - machine produced crop group stratification label
- ANALYST LABEL** - label given a blob by the Analyst, determined by a structured/objective decision logic
- LABEL** - estimate of crop type/crop class proportions present in a blob
- MIXED BLOB** - blob in which more than one crop type/crop class is present
- UNSAMPLED STRATUM** - little blobs are not sampled and labeled
- CONVERGENCE OF EVIDENCE** - progressive accumulation of evidence or probabilities supporting the determination of a particular fact  
(e.g., this blob is corn)



LEVEL	TYPE	TYPE CODE	REGION	CROP PROC.	NO.	VAR.	PROCEDURE NAME	DATE
SUBSYSTEM	AREA ESTIMATION	A	U.S.	C/S	1		CORN/SOYBEANS BASELINE	8/21/81

- (1) Historical crop stage data at lowest possible geopolITICAL level. Development stage model output at segment level. All possible crops.
- (2) Manual image screen to delete excessive cloud cover and bad data and to manually select candidate acquisitions based on crop calendar and imagery data in an interactive analysis.
- (3) Screen algorithm for cloud identification. Sensor calibration, Sun-angle correction, and XSTAR haze correction.
- (4) Temporal pattern class (TPC) features extracted in transformed brightness/C R ABS space for each pixel.
- (5) Temporal pattern clas: feature report summarizing multi temporal vegetation/nonvegetation.
- (6) Manual stratification of TPC into major crop groups for delta function stratification. Manual selection of TPC for blob labeling spectral aids (scatterplots).
- (7) Stratified spectral aids development (generation of DFS report and scatterplots).
- (8) Delta function stratification (DFS) report for major crop groups (summer crops).
- (9) Manual determination of corn/soybeans discriminant line.
- (10) Manual determination of acquisition with best corn/soybean separation. Selection of acquisition subset for determining field-like patterns (blobs).
- (11) Target definition through clustering into "blob". Two groups formed based on "blob" size. Stratification of big blobs by crop group. "Blobs" selected for labeling based on proportional sampling of stratum size.
- (12) Preliminary (Stage 1) labeling of pixels by machine.
- (13) Spectral labeling aids and PFC overlay for selected blobs.
- (14) Manual final labeling of blobs and indication of confidence in label.
- (15) Weighted aggregation of blob labels (large blobs).
- (16) Segment proportion estimate by extension labeled blobs to unsampled (little) blobs and aggregating stratum providing estimates of corn/soybeans or summer crops.

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## KEY TECHNICAL CONCEPTS

- Stratified Areal Estimation
- Physically-based Feature Extraction
- Convergence of Evidence Labeling
- Treatment of Mixed and Boundary pixels

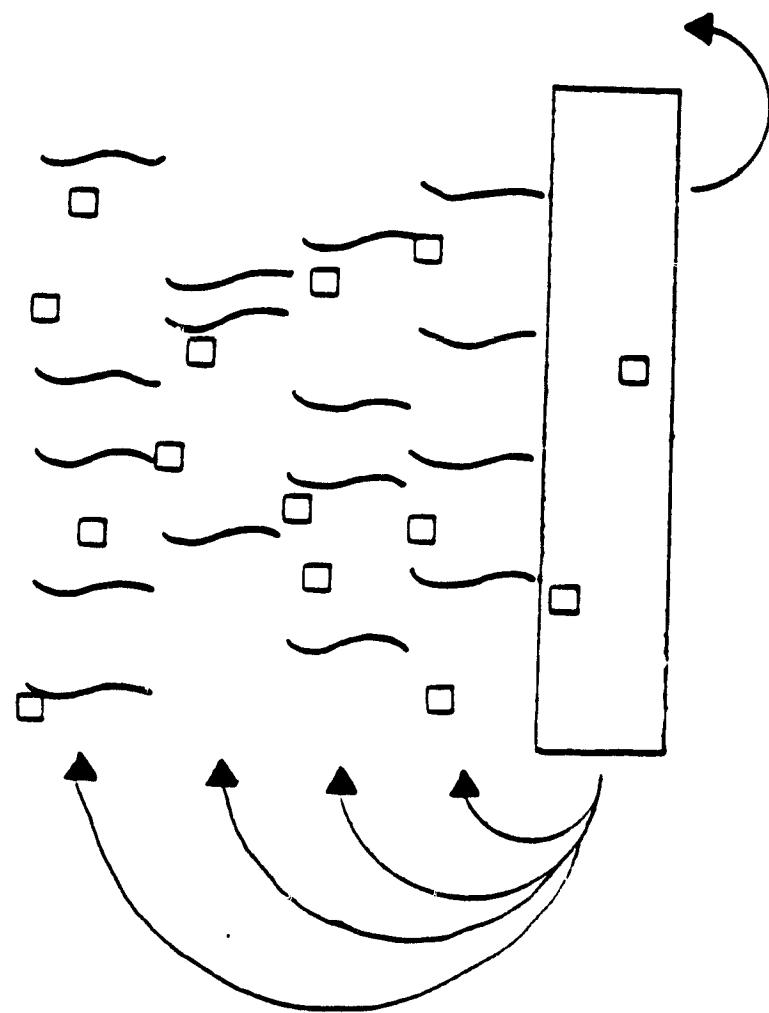
## STRATIFIED AREAL ESTIMATION

- Data is Stratified by Crop Group
- "Blobs" Formed from Spectrally Similar, Spatially Contiguous Pixels
- Blobs Which are Temporally/Spectrally Similar are Clustered Together
- A Sample of the Blobs with Interiors is Presented for labeling
- Labeled Blobs Give Estimate of Crop Proportions in Clusters, Which Gives Estimate of Proportions in Crop Group, Which Gives Estimate for Segment

**BASELINE CORN/SOYBEANS STRATIFICATION  
& SAMPLING**

Big Fields		"Little" Fields	
Summer Crop			
Spring Crop			
Pasture/Grass			
Non-Vegetated			
Unknown			

3.11



### C/S-1 ESTIMATOR

$$P = \frac{\sum_{DFS} p_i (A_i + A'_i)}{\sum_{DFCS} (A_i + A'_i)}$$

where

$$p_i = \frac{\sum_{\text{cluster}} p_{ij} A_{ij}}{\sum_{\text{cluster}} A_{ij}}$$

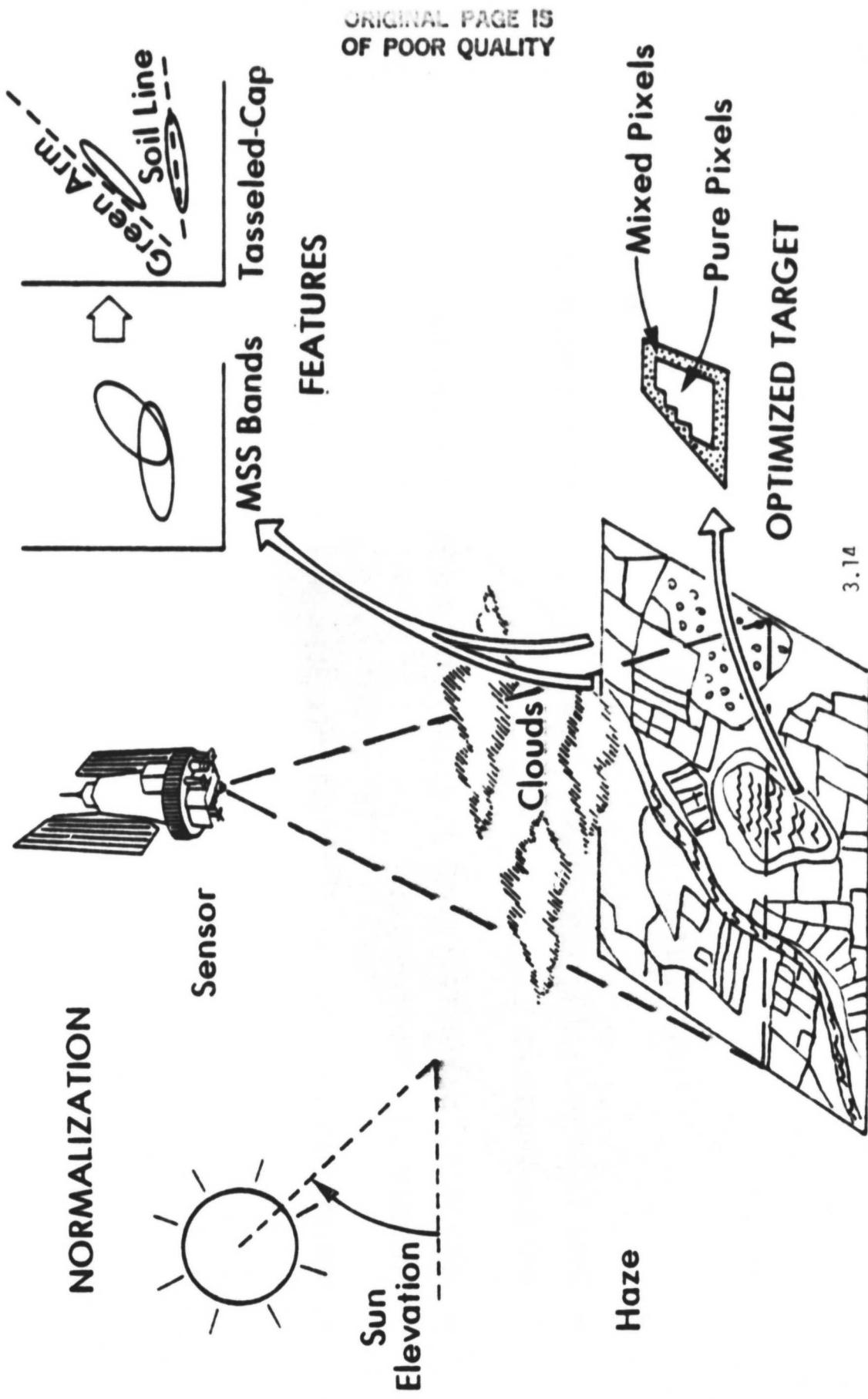
$A$  is area of sampled clusters

$A'$  is area of unsampled strata

## PHYSICALLY BASED FEATURES

- Landsat Data is Normalized to Standard Sun Angle, Satellite, and Atmospheric Conditions to Minimize Effects That are Noise with Respect to the Information Requirement
- Features Which are Indicators of Crop Development are Extracted that Multi-Temporally Represent Crop Phenological Growth

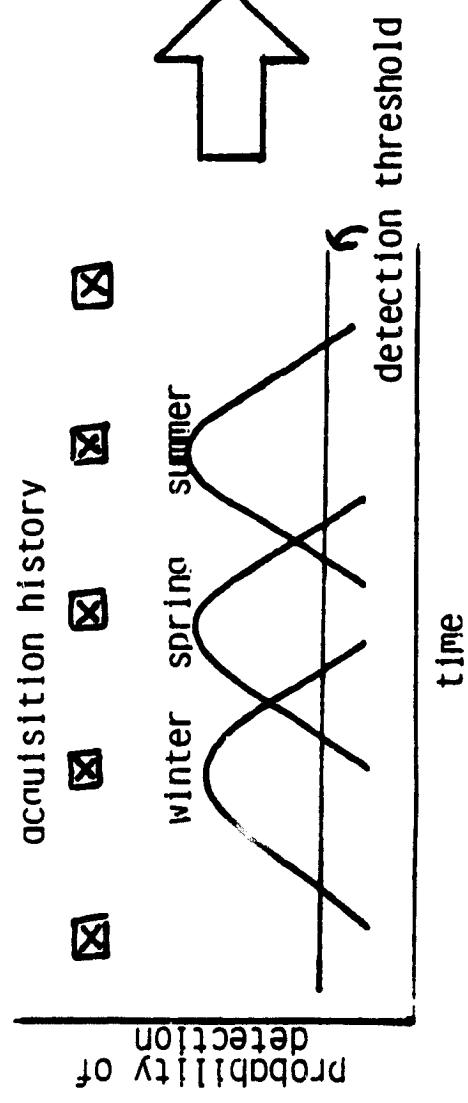
## PHYSICALLY BASED FEATURES



## CONVERGENCE OF EVIDENCE LABELING

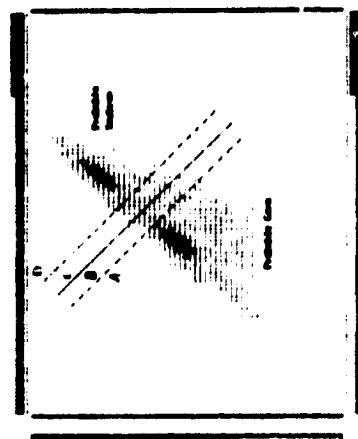
- Data is Stratified by Crop Group: Summer, Grain, Permanent Vegetation and Non-Vegetated
- Data Within Summer Crop Group is Stratified into Probable Corn and Probable Soy: Machine Labels
- Analyst Assigns Final Label by Following Objective Decision Logic

## LABELING PROCESS

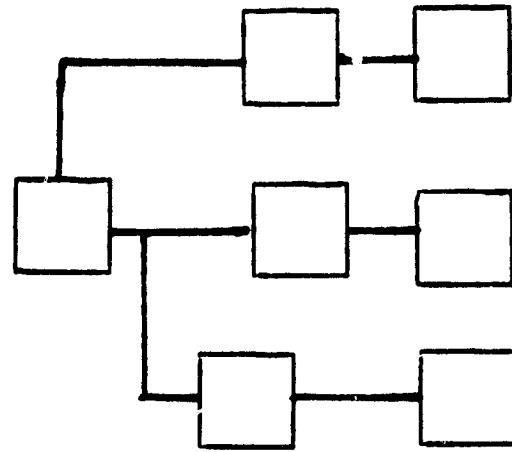


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winter crop	0	1	0	0	0
spring crop	0	0	1	0	0
summer crop	0	0	0	1	0



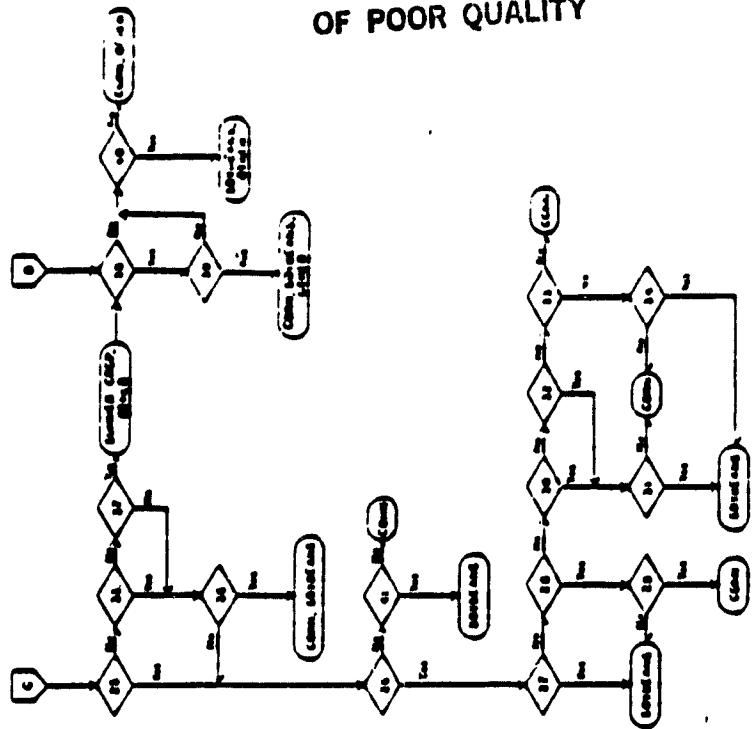
Brightness



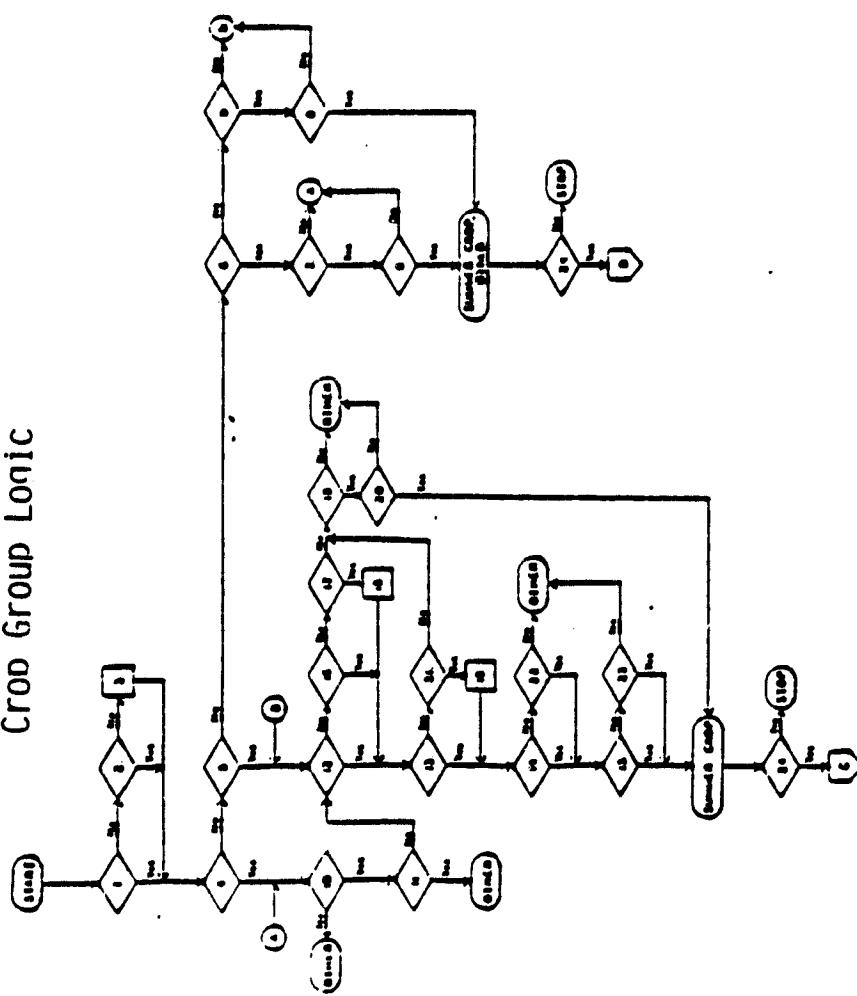
Analyst Label

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DECISION LOGIC  
Analyst Label



Crop Group Logic

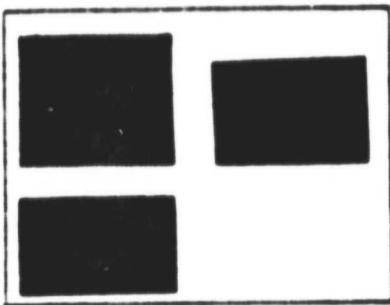


## TREATMENT OF MIXED AND BOUNDARY PIXELS

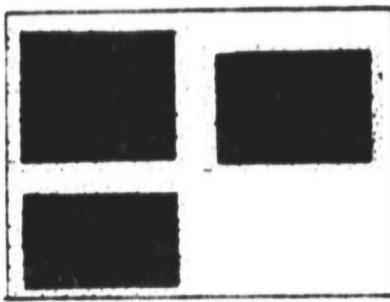
- The Scene Is Spatially/Spectrally Clustered into Field-Like Patterns
- The Patterns are Divided into Field Interiors, Boundaries and Mixed Patterns (or little blobs)
- Only Field Interiors are Labeled, Those Labels Extended to the Remainder of the Scene

Machine:	Analyst:	Label	---	---	---
Unbiased Sample	Spectral/Spatial Label Extension	(40%)	Big Blob Boundaries	(40%)	Big Blob Interiors (40%)
					Little Blobs (20%)

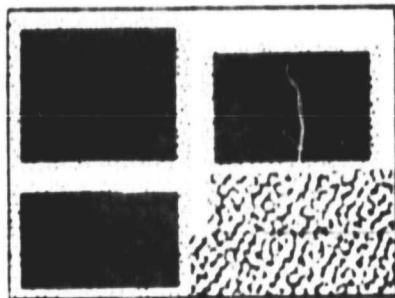
1. SAMPLE AND LABEL BIG BLOB INTERIORS



2. EXTEND INTERIOR LABEL TO BOUNDARY

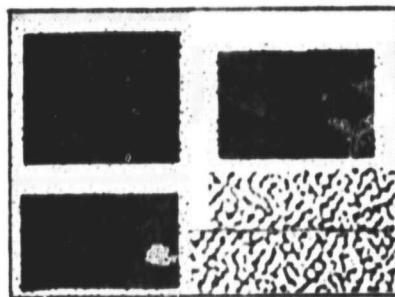


3. ASSIGN PROPORTIONAL LABEL TO REMAINING UNSAMPLED BIG BLOBS IN CLUSTERS

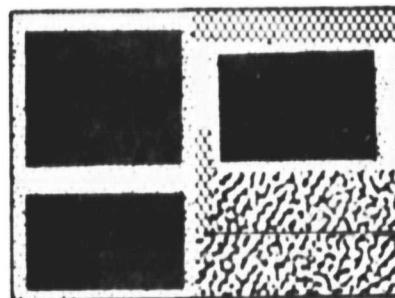


3.19

4. ASSIGN DFS PROPORTION TO LITTLE BLOBS



5. ASSIGN PROPORTIONAL LABEL TO REMAINING BLOBS ASSIGNED TO "UNKNOWN" DFS



6. FINAL SEGMENT ESTIMATE

# PROPORTION ESTIMATION EFFICIENCY

K. S. NEDELMAN  
9/29/81

3.20

### 3.2 PROCEDURE PERFORMANCE EVALUATIONS

- ⇒ O PROPORTION ESTIMATION EFFICIENCY
- ⇒ O RATE OF PROCESSABILITY
- O PROPORTION ESTIMATION ACCURACIES FOR c/s-1 IN CROP YEARS  
1978 AND 1979
- O EFFECT OF DIFFERENT TARGET LABELING SOURCES
- O EFFECT OF TREATMENT OF UNSAMPLED PORTION OF THE SCENE
- O EFFECT OF ANALYST TEAMS
- O ANALYST LABELING PERFORMANCE
- O RELATIONSHIP BETWEEN LABELING TARGET SIZE AND PROPORTION  
ESTIMATION ERROR

TEST NO.	TEST TYPE	CRGP PROCEDURE/NAME	PROC. TYPE	TEST LEVEL	TEST REGION	SECS.	YEARS.	DAT.	TEST NO. 3
7	PILOT	U.S. CORN/SOYBEANS BASELINE PROCEDURE C/S-1	AREA ESTIMATION	SUBSYSTEM	U. S. CENTRAL	26	73-79	522111070000000000	TEST NO. 3

#### PROCEDURES EFFICIENCY REPORT

##### BACKGROUND:

- THE U. S. CORN AND SOYBEANS BASELINE PROCEDURE (CS1) IS THE FIRST PROCEDURE IMPLEMENTED TO PRODUCE A SEGMENT-LEVEL AREA PROPORTION ESTIMATE. EFFICIENCY DATA IS NECESSARY TO PROVIDE INSIGHT INTO AFFORDABILITY AND TO CONSTITUTE A BASELINE FOR COMPARISON OF ADDITIONAL PROCEDURES.

##### OBJECTIVES:

- TO OBTAIN QUANTITATIVE MEASUREMENTS OF EFFICIENCY IN CORN AND SOYBEANS PROCEDURES.
- TO DEFINE STANDARD METHODS FOR OBTAINING AND DOCUMENTING MEASUREMENTS OF EFFICIENCY.
- TO OBTAIN EFFICIENCY DATA AT SUBCOMPONENT LEVELS TO IDENTIFY AREAS WHERE EFFICIENCY CAN BE IMPROVED.

##### CONCLUSION:

- QUANTITATIVE MEASUREMENTS HAVE BEEN DOCUMENTED FOR CS1. THESE MEASUREMENTS HAVE BEEN AND WILL CONTINUE USEFUL IN COMPARISON TO OTHER PROCEDURES.

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TEST NO.	TEST TYPE	CROP PROCEDURE/NAME	PROC. TYPE	TEST LEVEL	TEST REGION	SEGS.	YEAR(S)	DATE	TEST PERIOD
7	PILOT	CS1 U.S. CORN AND SOYBEANS BASELINE	AREA ESTIMATION	SUBSYSTEM	U.S. CENTRAL CORN BELT	28	1978/ 1979	9/29/81 3/81	10/81

**PROCEDURES EFFICIENCY DATA**

CS1 SUMMARY	
DATA PREPARATION (HISTORICAL CROP CALENDARS)	1 HOUR 15 MINUTES
MANUAL	TURNAROUND = 13.5 DAYS
PROCEDURE EXECUTION	15 HOURS 10 MINUTES
MANUAL	
COMPUTER	BATCH:  INTERACTIVE:  23:51 MINUTES CPU 12:00 MINUTES CONNECT
	2:10 MINUTES CPU 85:00 MINUTES OPERATOR

TEST NO.	TEST TYPE	CROP PROCEDURE/NAME	PROC. TYPE	TEST LEVEL	TEST REGION	DATA SET	DATE	TEST PERIOD
7	PILOT	U.S. CORN/SOYBEANS BASELINE PROCEDURE C/S-1	AREA ESTIMATION	SUBSYSTEM	U.S. CENTRAL CORN BELT	SEGS. ACOS.	9/28/81	FROM TO 10/80 10/81

**PROCEDURES EFFICIENCY DATA**

GROUP NO.	FUNCTION NAME	ANALYST		TECHNICIAN/CLERICAL			COMPUTER OPS.			TURN- AROUND TIME (DAYS)			
		CONTACT	CLER.	QA	DATA HANDLING, STATUS, TRACKING	CLERICAL	TECHNICIAN	CPU	BATCH	INTERACTIVE	CPU	OPR.	
		MIN	MIN	MIN	MIN	MIN	MIN	MIN: SEC	MIN: SEC	MIN: SEC	MIN: SEC	MIN: SEC	
1	HISTORICAL CROP CALENDAR	01:00			00:15								1
2	INITIAL SEGMENT ANALYSIS	04:32*			00:10			00:01					1
3-5	PREPROCESSING				00:02			00:01					1
6	CROP GROUP STRATIFICATION	00:48*			00:10			00:01					
7-8	PREPARATION OF SPECTRAL AIDS				00:04			00:01					
9-10	SPECIFICATION OF BLOB AND SEPARA- TION ACQUISITIONS	00:56*			00:04			00:01					
11-13	SPECTRAL STRATIFI- CATION AND SAMPLING PFC GENERATION				00:02			00:01					6.5
14	BLOB LABELING	08:07			00:02			00:01					
15-16	LABEL ENTRY AND ESTIMATION				00:10			00:01					3
													1
	<b>TOTAL</b>	15:23			00:55			00:07					13.5
								23:51					3.24

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\* Step performed by two-person team.  
Figure represents time for two people.

### **EXPECTED CSI PROCESSABILITY OF 1980 DATA**

- THE 1980 U.S. CENTRAL CORN BELT SEGMENTS WERE ALLOCATED BY STRATIFIED RANDOM SAMPLING WITH MULTICROP OPTIMAL ALLOCATION TO REFINED STRATA.

- A DATA ASSESSMENT WAS PERFORMED ON THESE SEGMENTS TO DETERMINE PROCESSABILITY RATES AND TO SUPPORT DATA PREPARATION. THE RESULTS:

**CSI PROCESSABILITY OF 1980 U.S. CENTRAL CORN BELT DATA**

	IOWA 1980	ILLINOIS 1980	INDIANA 1980	TOTALS
SEGMENTS ALLOCATED	69	78	37	184
SEGMENTS SCREENED*	69	76	32	177
SEGMENTS PROCESSABLE TO CROP GROUP (SC/0)	53	59	21	133
SEGMENTS PROCESSABLE TO CROP TYPE (C/S/0)	47	46	12	111

\*ONLY SEGMENTS WHICH HAD TWO OR MORE AQUISITIONS ACQUIRED WERE SCREENED.

## **PROCEDURE PERFORMANCE EVALUATIONS**

3.26

D. NORWOOD  
9/29/81

### 3.2 PROCEDURE PERFORMANCE EVALUATIONS

- o STANDARD STATISTICAL MEASURES
- o ACCURACY ASSESSMENT METHODOLOGY
- ▷ o PROPORTION ESTIMATION ACCURACIES FOR C/S-1 IN CROP YEARS  
1978 AND 1979
- ▷ o EFFECT OF DIFFERENT TARGET LABELING SOURCES
- ▷ o EFFECT OF TREATMENT OF UNSAMPLED PORTION OF THE SCENE
- ▷ o EFFECT OF ANALYST TEAMS
- ▷ o TARGET LABELING PERFORMANCE
- ▷ o RELATIONSHIP BETWEEN LABELING TARGET SIZE AND PROPORTION  
ESTIMATION ERROR

STANDARD STATISTICAL MEASURES OF ARFA PROPORTION  
ESTIMATION PERFORMANCE FOR  $n$  SEGMENT PROCESSINGS

- MEAN ERROR ( $\bar{e}$ ):  $\sum_{i=1}^n e_i / n = \bar{p} - \tilde{p}$
- STANDARD DEVIATION OF ERRORS ( $s_e$ ):  $[\sum_{i=1}^n (e_i - \bar{e})^2 / (n-1)]^{1/2}$
- MEAN ABSOLUTE ERROR (M.A.E.):  $\sum_{i=1}^n |e_i| / n$
- RELATIVE MEAN ERROR (R.M.E.):  $\bar{e}/\bar{p}$
- "IMPROVEMENT" OF #2 ESTIMATES OVER #1 ESTIMATES ( $\bar{t}$ ):  

$$\sum_{i=1}^n (|e_i|_{#1} - |e_i|_{#2}) / n = M.A.E._{#1} - M.A.E._{#2}$$

- \* Denotes statistically significant at 90% confidence level
- \*\* Denotes statistically significant at 95% confidence level

GROUND TRUTH PROPORTION FOR  $i$  TH SEGMENT:

ESTIMATED PROPORTION FOR  $i$  TH SEGMENT:

$$e_i = \hat{p}_i - p_i$$

ABSOLUTE ERROR FOR  $i$  TH SEGMENT:

$$|e_i|$$

$$\bar{p} = \sum_{i=1}^n p_i / n$$

$$\tilde{p} = \sum_{i=1}^n \hat{p}_i / n$$

MEAN ESTIMATED PROPORTION:

3.28

## ACCURACY ASSESSMENT METHODOLOGY

- 0 GROUND TRUTH SEGMENT PROPORTIONS BASED ON GROUND OBSERVATION DATA,  
RECORDED IN DIGITAL FORM ON UNIVERSAL GROUND TRUTH TAPE (U.G.T.T.)
  - GROUND TRUTH PROPORTION FOR CORN DEFINED TO BE THE SUM OF THE  
CORN AND SORGHUM PROPORTIONS (VERY LITTLE SORGHUM PRESENT)
  - GROUND TRUTH PROPORTION FOR SOYBEANS DEFINED TO INCLUDE SOYBEANS  
PROPORTION ONLY
  - GROUND TRUTH PROPORTION FOR SUMMER CROPS DEFINED TO BE SUM OF CORN  
AND SOYBEANS GROUND TRUTH PROPORTIONS AS DEFINED ABOVE
  - NON-INVENTORIED PORTION OF EACH SEGMENT ASSUMED TO HAVE THE SAME  
PROPORTIONS OF CROPS AS THE INVENTORIED PORTION OF THE SEGMENT.

PERCENT OF SEGMENT NOT INVENTORIED DURING GROUND OBSERVATIONS  
 FOR THE EIGHTEEN SEGMENTS FROM CROP YEAR 1978

<u>SEGMENT</u>	<u>PERCENT</u>	<u>SEGMENT</u>	<u>PERCENT</u>
123	5.63	837	2.64
133	4.05	842	2.75
141	1.25	852	2.21
144	5.23	853	1.98
202	6.00	864	2.31
205	9.58	865	1.74
800	2.99	877	21.61
807	8.29	880	2.19
832	2.77	881	1.96

RANGE: 1.25% to 21.61%

MEDIAN: 2.76%

9/29/81

3.30

- 0 "GROUND TRUTH LABELS" FOR TARGETS DETERMINED BY GROUND TRUTH PROPORTIONS OF CORN, SOYBEANS, AND OTHER IN TARGET INTERIOR
  - ACCORDING TO CRITERIA CONSISTENT WITH C/S-1 LABELING DECISION LOGIC AND INSTRUCTIONS TO ANALYSTS
  - GROUND TRUTH PROPORTIONS OF C, S, O IN EACH TARGET INTERIOR ADJUSTED ACCORDING TO ANALYST LABEL IF PARTLY OR ENTIRELY NON-INVENTORIED
  - THIRTEEN PERMISSIBLE TARGET LABELS REPRESENTING DISCRETE APPROXIMATIONS OF ACTUAL PROPORTIONS IN TARGET INTERIOR; E.G.,
    - + "C" MEANS AT LEAST 2/3 CORN AND LESS THAN 1/3 OF EACH OF SOYBEANS AND OTHER
    - + "CO" MEANS APPROXIMATELY 50% CORN AND 50% OTHER
    - + "CCO" MEANS APPROXIMATELY 2/3 CORN AND 1/3 OTHER

- 0 PROPORTION ESTIMATES GENERATED BY AREA PROPORTION ESTIMATION SCHEME OF THE PROCEDURE WHEN TARGETS ARE GIVEN "GROUND TRUTH LABELS"
  - AN INDICATION OF THE BIAS INHERENT IN THE PROPORTION ESTIMATION SCHEME (NO CONTRIBUTION DUE TO LABELING ERRORS)
  - A BASIS FOR ASSESSING THE CONTRIBUTION OF ANALYST LABELING ERRORS TO C/S-1 PROPORTION ESTIMATION ERROR
  
- 0 PROPORTION ESTIMATES GENERATED BY THE AREA PROPORTION ESTIMATION SCHEME WHEN TARGETS ARE GIVEN "MACHINE 'ABELS'"
  - FOR COMPARISON WITH ESTIMATES GENERATED FROM ANALYST LABELS, AS AN INDICATION OF IMPROVEMENT DUE TO THE DIFFERENCE BETWEEN THE ACCURACIES OF ANALYST AND MACHINE LABELS

PROPORTION ESTIMATION ACCURACIES FOR C/S-1 IN CROP YEARS 1978 AND 1979

CROP YEAR 1978:

- 0 CORN OVERESTIMATED BY 15.0% R.M.E.
- 0 SOYBEANS UNDERESTIMATED BY 18.7% R.M.E.
- 0 NO DISCERNIBLE BIAS FOR SUMMER CROPS (-1.5% R.M.E.)

CROP YEAR 1979:

- 0 CORN OVERESTIMATED BY 6.0% R.M.E. (NOT STATISTICALLY SIGNIFICANT)
- 0 SOYBEANS UNDERESTIMATED BY 3.0% R.M.E. (NOT STATISTICALLY SIGNIFICANT)
- 0 SUMMER CROPS OVERESTIMATED BY 1.8% R.M.E. (STATISTICALLY SIGNIFICANT, BUT NEGIGIBLE)

## PERFORMANCE OF C/S-1 IN CROP YEAR 1978

### SUMMARY STATISTICS

$\bar{e}$	5.3**
$S_e$	4.8
M.A.E.	6.2
R.M.E.	15.0
$\bar{P}$	35.2
n	30

CORN

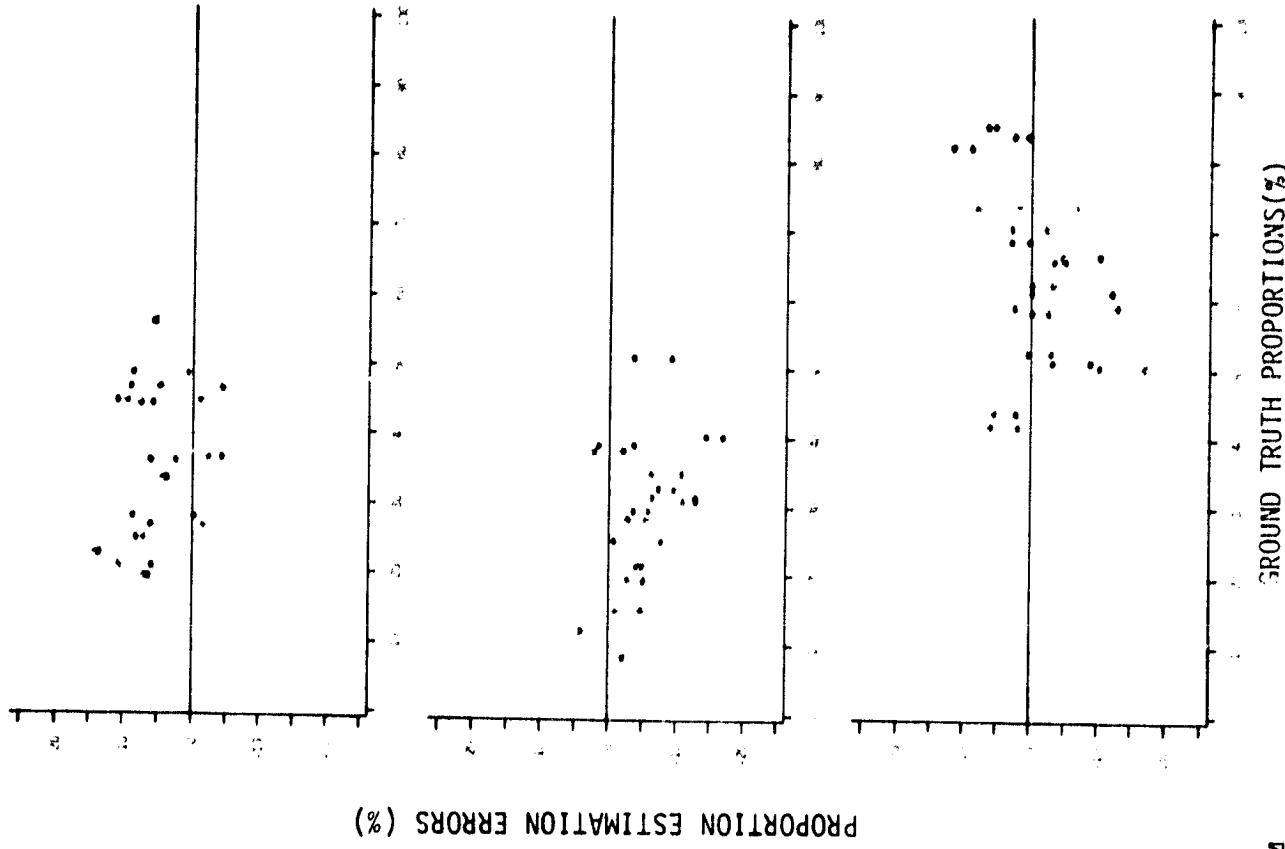
$\bar{e}$	-5.5**
$S_e$	4.9
M.A.E.	6.1
R.M.E.	-18.7
$\bar{P}$	29.7
n	30

SOYBEANS

$\bar{e}$	-0.9
$S_e$	6.5
M.A.E.	4.9
R.M.E.	-1.5
$\bar{P}$	63.8
n	36

SUMMER CROPS

### SUMMARY SEGMENT PROPORTION ESTIMATION ERRORS VS. GROUND TRUTH PROPORTIONS



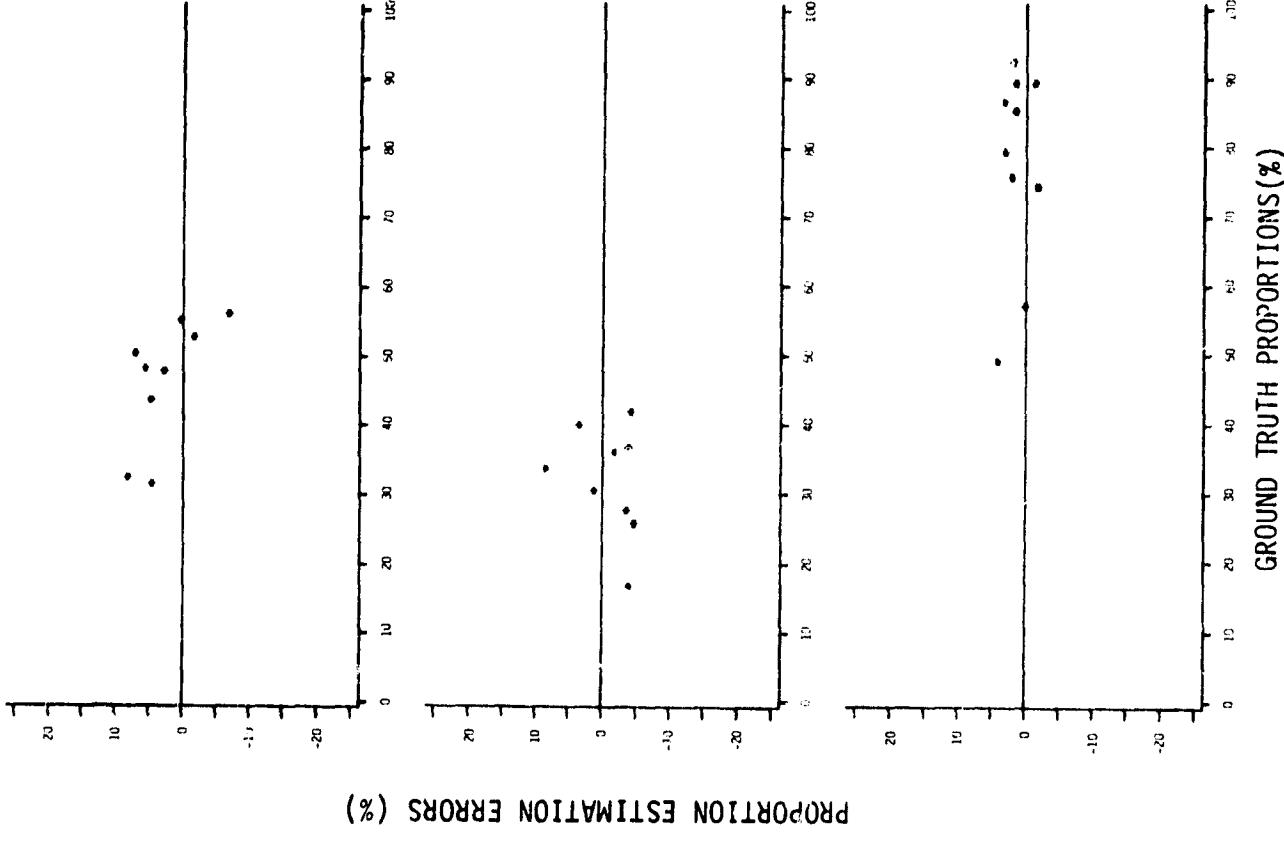
PROPORTION ESTIMATION ERRORS (%)

## PERFORMANCE OF C/S-1 IN CROP YEAR 1979

### SUMMARY STATISTICS

$\bar{e}$	2.8
$S_e$	4.8
M.A.E.	4.7
R.M.E.	6.0
$\bar{P}$	46.3
n	9

### SEGMENT PROPORTION ESTIMATION ERRORS VS. GROUND TRUTH PROPORTIONS



**CORN**  
**SOYBEANS**  
**SUMMER CROPS**

COMPARISON OF PERFORMANCE BETWEEN YEARS

O INDICATIONS OF A DIFFERENCE IN PERFORMANCE OF C/S-1 IN CROP  
YEARS 1978 AND 1979

- DIRECTION OF BIAS IN ESTIMATES APPEARS TO BE CONSISTENT  
BETWEEN CROP YEARS
- APPARENT IMPROVEMENT IN 1979 IN ALL MEASURES OF BIAS FOR  
CORN AND SOYBEANS
- STANDARD DEVIATIONS OF THE ERRORS REMAINED COMPARABLE  
IN BOTH CROP YEARS FOR EACH OF CORN AND SOYBEANS
- NEGLIGIBLE DECREASE IN ACCURACY ACCCOMPANIED BY AN APPARENT  
REDUCTION IN THE STANDARD DEVIATION OF SUMMER CROP ERRORS  
IN 1979

O COMPARISON OF PROPORTION ESTIMATION PERFORMANCE OF C/S-1 AND TY  
EXPLORATORY EXPERIMENT "P.V.T." (PROCEDURES VERIFICATION TEST)

WITH ANALYST LABELS:

- P.V.T. UNDERESTIMATED BOTH CORN (2.7%) AND SOYBEANS (5.9%) FOR  
30 SEGMENT PROCESSINGS, AND ALSO SUMMER CROPS (10.4%) FOR 36  
SEGMENT PROCESSINGS
- C/S-1, FOR THE SAME SETS OF SEGMENT PROCESSINGS:
  - + IMPROVED SUBSTANTIALLY UPON THE P.V.T. SUMMER CROP ERRORS  
(C/S-1 UNDERESTIMATED BY 0.9%), WITH A 25% LOWER STANDARD DEVIATION
  - + MAINTAINED THE SAME ACCURACY OF P.V.T. ERRORS FOR SOYBEANS  
(C/S-1 UNDERESTIMATED BY 5.5%), WITH A 34% LOWER STANDARD DEVIATION
  - + OVERESTIMATED CORN (5.3%) BY MORE THAN P.V.T. UNDERESTIMATION OF CORN  
(2.7%), WITH A 17% LOWER STANDARD DEVIATION OF ERRORS

WITH GROUND TRUTH LABELS:

- + P.V.T. WAS ESSENTIALLY UNBIASED AS AN ESTIMATOR OF CORN, SOYBEANS, AND SUMMER CROPS.
- + C/S-1 SAMPLES A BIASED PORTION (BIG BLOBS) OF THE SCENE, AND PRODUCES BIASED ESTIMATES OF ITS PROPORTIONS FOR CORN AND FOR SOYBEANS, BUT NOT FOR SUMMER CROPS.
- + A SUBSTANTIALLY LOWER STANDARD DEVIATION OF ERRORS FOR CORN WAS OBSERVED (2.1% FOR C/S-1, 4.5% FOR P.V.T.); LESS SUBSTANTIAL IMPROVEMENTS WERE OBSERVED FOR SOYBEANS AND FOR SUMMER CROPS.

NOTE: VARIABILITY WAS INTRODUCED BY FIELD SIZE DISTRIBUTIONS THROUGH THE TREATMENT OF THE UNSAMPLED PORTION OF THE SCENE (LITTLE BLOBS), AS WILL BE EXPLAINED BY M. METZLER OF ERIM LATER IN THIS PRESENTATION.

**COMPARISON OF PERFORMANCE FOR CORN**

C/S-1 VS. PVT (PROCEDURES VERIFICATION TEST)

CROP YEAR 1978

	WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
	C/S-1	PVT	C/S-1	PVT
$\bar{e}$	5.3**	-2.7**	3.9**	-1.3
$S_e$	4.8	5.8	2.1	4.5
M.A.E.	6.2	5.3	3.9	3.7
R.M.E.	15.0	-7.7	11.0	-3.6
$\bar{P}$	35.2	35.2	35.2	35.2
n	39	30	30	30

IMPROVEMENT ( $\bar{I}$ ):  
C/S-1 OVER PVT

-0.9

-0.1

**COMPARISON OF PERFORMANCE FOR SOYBEANS**

C/S-1 VS. PVT (PROCEDURES VERIFICATION TEST)

CROP YEAR 1978

	WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
	C/S-1	PVT	C/S-1	PVT
$\bar{e}$	-5.5**	-5.8**	-3.0**	-0.2
$S_e$	4.9	7.4	2.3	2.7
M.A.E.	6.1	7.3	3.3	2.3
R.M.E.	-18.7	-19.7	-10.0	-0.7
$\bar{p}$	29.7	29.7	29.7	29.7
n	30	30	30	30

IMPROVEMENT ( $I$ )  
C/S-1 OVER PVT

1.2

-1.0\*

**COMPARISON OF PERFORMANCE FOR SUMMER CROPS**

C/S-1 VS. PVT (PROCEDURES VERIFICATION TEST)

CROP YEAR 1978

	WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
	C/S-1	PVT	C/S-1	PVT
$\bar{e}$	-0.9	-10.4**	0.8	-1.8**
$S_e$	6.5	8.7	3.0	4.0
M.A.E.	4.9	11.1	2.6	3.6
R.M.E.	-1.5	-16.4	1.2	-2.8
$\bar{P}$	63.8	63.8	64.5	64.5
n	36	36	34	34

IMPROVEMENT ( $\bar{I}$ )  
C/S-1 OVER PVT

0.2\*\*

1.0\*\*

0 EFFECT ON C/-1 PROPORTION ESTIMATION ERRORS OF DIFFERENT TARGET LABELING  
SOURCES: GROUND TRUTH, ANALYST, MACHINE

- PROPORTION ESTIMATION ERRORS WHEN TARGETS ARE GIVEN GROUND TRUTH LABELS
  - + OVERESTIMATION OF CORN IN BOTH CROP YEARS 1973 AND 1979: STATISTICALLY SIGNIFICANT IN BOTH CROP YEARS
    - SUBSTANTIAL (11.0% R.M.E.) IN 1978, LESS SUBSTANTIAL (6.8% R.M.E.) IN 1979.
  - + UNDERESTIMATION OF SOYBEANS IN BOTH CROP YEARS:
    - STATISTICALLY SIGNIFICANT IN BOTH CROP YEARS
      - SUBSTANTIAL (-10.0% R.M.E.) IN 1978, LESS SUBSTANTIAL (-6.1% R.M.E.) IN 1979
  - + NO SUBSTANTIAL ERROR IN ESTIMATING SUMMER CROPS IN EITHER CROP YEAR

- CHANGES IN PROPORTION ESTIMATION ERRORS DUE TO ANALYST RATHER THAN GROUND TRUTH LABELING VARIED WITH CROP YEAR
  - + CORN: INCREASE IN MAGNITUDE OF OVERESTIMATION IN CROP YEAR 1978; INDICATION OF SLIGHT DECREASE IN MAGNITUDE OF OVERESTIMATION IN 1979
  - + SOYBEANS: INCREASE IN MAGNITUDE OF UNDERESTIMATION IN CROP YEAR 1978; INDICATION OF SLIGHT DECREASE IN MAGNITUDE OF UNDERESTIMATION IN 1979.
  - + SUMMER CROPS: NO SUBSTANTIAL CONTRIBUTION TO ERROR IN EITHER CROP YEAR.
  - + STANDARD DEVIATIONS OF ERRORS: SOMEWHAT GREATER WITH ANALYST LABELS FOR EACH CROP CATEGORY IN EACH CROP YEAR (EXCEPT SUMMER CROPS IN 1979).
- IMPROVEMENTS DUE TO ANALYST RATHER THAN MACHINE LABELING WERE CONSISTENT FROM YEAR TO YEAR.
- + CORN: SUBSTANTIAL IMPROVEMENT IN BOTH CROP YEARS, IN MEAN ERROR AND STANDARD DEVIATION.
  - + SUMMER CROPS: SUBSTANTIAL IMPROVEMENT IN BOTH CROP YEARS, IN MEAN ERROR AND STANDARD DEVIATION, DUE TO CORN.
  - + SOYBEANS: NO SIGNIFICANT IMPROVEMENT IN EITHER CROP YEAR, IN MEAN ERROR OR STANDARD DEVIATION.

EFFECT OF DIFFERENT SOURCES OF TARGET LABELS  
ON PERFORMANCE OF C/S-1 FOR CORN

SOURCE	1978: $\bar{P}=35.2$		n=30	1979: $\bar{P}=46.3$		$n=9$
	MACHINE	ANALYST	GROUND TRUTH	MACHINE	ANALYST	
$\bar{e}$	9.3**	5.3**	3.9**	10.0**	2.8	3.2**
$S_e$	7.2	4.8	2.1	12.7	4.8	2.2
M.A.E.	9.9	6.2	3.9	10.7	4.7	3.2
R.M.E.	26.3	15.0	11.0	21.5	6.0	6.8

IMPROVEMENT ( $\bar{I}$ ): 

3.7**	2.3**
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6.0	1.5
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EFFECT OF DIFFERENT SOURCES OF TARGET LABELS  
ON PERFORMANCE OF C/S-1 FOR SOYBEANS

SOURCE	1978: $\bar{P}=29.7$		n=30		1979: $\bar{P}=32.0$		$n=9$
	MACHINE	ANALYST	GROUND TRUTH	MACHINE	ANALYST	GROUND TRUTH	
$\bar{e}$	-5.8**	-5.5**	-3.0**	-1.0	-1.0	-1.0	-1.9**
$S_e$	5.0	4.9	2.3	4.6	4.5	4.5	2.5
M.A.E.	6.3	6.1	3.3	3.8	3.9	3.9	2.7
P.M.E.	-19.4	-18.7	-10.0	-3.2	-3.0	-3.0	-6.1

IMPROVEMENT ( $\bar{I}$ ):

0.2	2.8**	-0.1	1.2
-----	-------	------	-----

EFFECT OF DIFFERENT SOURCES OF TARGET LABELS  
ON PERFORMANCE OF C/S-1 FOR SUMMER CROPS

SOURCE	1978: $\bar{P}=63.8$		n=36		1979: $\bar{P}=77.9$		$n=10$
	MACHINE	ANALYST	GROUND TRUTH	MACHINE	ANALYST	GROUND TRUTH	
$\bar{e}$	3.1	-0.9	0.7	3.6**	1.4*	1.6	
$S_e$	11.9	6.5	3.0	10.7	2.0	3.3	
M.A.E.	8.9	4.9	2.5	8.7	2.1	3.2	
R.M.E.	4.9	-1.5	1.0	11.1	1.8	2.0	

IMPROVEMENT ( $\bar{I}$ ):

4.0**	2.4**
6.5*	-1.1*

0 EFFECT OF TREATMENT OF THE UNSAMPLED PORTION OF THE SCENE BY C/S-1  
PROPORTION ESTIMATION SCHEME:

BIG BLOBS ONLY (B.B.O.) VS. LITTLE BLOBS WEIGHTED (L.B.W.)

--THE INITIAL ESTIMATES (B.B.C.) ARE DERIVED FROM SAMPLES TAKEN  
FROM A BIASED PORTION OF THE SCENE (BIG BLOBS ONLY), AND ARE  
BIASED WITH RESPECT TO THE ENTIRE SCENE (EVIDENCE TO BE DISCUSSED  
BY M. METZLER OF ERIM)

--THE B.B.O. ESTIMATES, ALTHOUGH THEY ARE NOT THE FINAL C/S-1  
ESTIMATES, ARE THE INITIAL ESTIMATES TO WHICH BIAS CORRECTIONS  
ARE APPLIED IN ORDER TO ARRIVE AT THE FINAL ESTIMATES (L.B.W.)

WITH ANALYST LABELS:

- THE L.B.W. ESTIMATES LOWER THE B.B.O. ESTIMATES FOR CORN AND FOR SOYBEANS
- + CORN: MAGNITUDE OF OVERESTIMATION DECREASED IN BOTH CROP YEARS, BUT  
REMAINS SIGNIFICANT AND SUBSTANTIAL IN 1973 (15.0% R.M.E.)
  - + SOYBEANS: MAGNITUDE OF UNDERESTIMATION INCREASED IN BOTH CROP  
YEARS, BECOMING IN 1978 AS LARGE IN TERMS OF R.M.E. AS THE B.B.O.  
CORN OVERESTIMATION (18.7% R.M.E.)
  - + SUMMER CROPS: NET LOWERING OF ESTIMATES IN BOTH CROP YEARS, BUT ERRORS  
REMAIN INSUBSTANTIAL
  - + STANDARD DEVIATIONS OF ERRORS FOR B.B.O. AND FOR L.B.W. REMAIN  
COMPARABLE WITHIN EACH CROP YEAR FOR EACH CROP CATEGORY

WITH GROUND TRUTH LABELS:

--THE L.B.W. ESTIMATES LOWER THE B.B.O. ESTIMATES FOR CORN AND FOR SOYBEANS.

- + CORN: MAGNITUDE OF OVERESTIMATION REDUCED IN BOTH CROP YEARS, BUT REMAINS SIGNIFICANT IN BOTH YEARS AND SUBSTANTIAL IN 1973 (11.3% R.M.E.)
- + SOYBEANS: MAGNITUDE OF UNDERESTIMATION INCREASED IN BOTH CROP YEARS, BECOMING 10.3% R.M.E. IN 1978.
- + SUMMER CROPS: NET LOWERING OF ESTIMATES, BUT ERRORS REMAIN INSUBSTANTIAL IN BOTH CROP YEARS.
- + STANDARD DEVIATIONS OF ERRORS FOR L.B.W. ARE EQUAL TO OR SLIGHTLY LOWER THAN THOSE FOR B.B.O. WITHIN EACH CROP YEAR FOR EACH CROP CATEGORY.

EFFECT OF TREATMENT OF UNSAMPLED PORTION  
OF THE SCENE BY C/S-1 ESTIMATES

BIG BLOBS ONLY (B.B.O.) VS. LITTLE BLOBS WEIGHTED (L.B.W.)  
CROP YEAR 1978

CORN: $\bar{P}=35.2$ $n=30$	WITH ANALYST LABELS			WITH GROUND TRUTH LABELS	
	B.B.O.	L.B.W.		B.B.O.	L.B.W.
$\bar{e}$	6.6**	5.3**		4.9**	3.9**
$S_e$	4.9	4.8		2.8	2.1
M.A.E.	7.1	6.2		4.9	3.9
R.M.E.	18.7	15.0		14.0	11.0

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

1.1\*\*

0.9\*\*

SOYBEANS: $\bar{P}=29.7$ $n=30$	WITH ANALYST LABELS			WITH GROUND TRUTH LABELS	
	B.B.O.	L.B.W.		B.B.O.	L.B.W.
$\bar{e}$	-4.9**	-5.5**		-2.4**	-3.0**
$S_e$	4.3	4.9		2.5	2.3
M.A.E.	5.4	6.1		3.0	3.3
R.M.E.	-16.4	-18.7		-8.2	-10.0

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

-0.2\*

-0.7\*\*

3.40

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OF POOR QUALITY.

EFFECT OF TREATMENT OF UNSAMPLED PORTION  
OF THE SCENE BY C/S-1 ESTIMATES

BIG BLOBS ONLY (B.B.O.) VS. LITTLE BLOBS WEIGHTED (L.B.W.)  
CROP YEAR 1979

CORN: $\bar{P}=46.3$ $n=9$	WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
	B.B.O.	L.B.W.	B.B.O.	L.B.W.
$\bar{e}$	3.6**	2.8	3.9**	3.2**
$S_e$	5.1	4.8	2.8	2.2
M.A.E.	5.3	4.7	3.0	3.2
R.M.E.	7.9	6.0	8.4	6.8

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

0.8\*\*

SOYBEANS: $\bar{P}=32.0$ $n=9$	WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
	B.B.O.	L.B.W.	B.B.O.	L.B.W.
$\bar{e}$	-0.5	-1.0	-1.5*	-1.9**
$S_e$	4.5	4.5	2.5	2.5
M.A.E.	3.7	3.9	2.5	2.7
R.M.E.	-1.6	-3.0	-4.7	-6.1

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

-0.2

3.50

ORIGINAL PAGE IS  
OF POOR QUALITY.

EFFECT OF TREATMENT OF UNSAMPLED PORTION  
OF THE SCENE BY C/S-1 ESTIMATES  
BIG BLOBS ONLY (B.B.O.) VS. LITTLE BLOBS WEIGHTED (L.B.W.)  
SUMMER CROPS

1978: $\bar{P}=63.8$ $n=36$		WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
		B.B.O.	L.B.W.	B.B.O.	L.B.W.
$\bar{e}$	1.1	-0.9		2.3**	0.7
$S_e$	5.8	6.5		3.6	3.0
M.A.E.	4.6	4.9		3.4	2.5
R.M.E.	1.7	-1.5		3.6	1.0

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

0.9\*\*

1979: $\bar{P} = 77.9$ $n = 10$		WITH ANALYST LABELS		WITH GROUND TRUTH LABELS	
		B.B.O.	L.B.W.	B.B.O.	L.B.W.
$\bar{e}$	2.8**	1.4**		2.9**	1.6
$S_e$	2.4	2.0		3.8	3.3
M.A.E.	2.9	2.1		4.2	3.2
R.M.E.	3.6	1.8		3.7	2.0

IMPROVEMENT ( $\bar{I}$ ):  
L.B.W. OVER B.B.O.

0.7

1.0\*

Q EFFECT OF DIFFERENT ANALYST TEAMS ON PROPORTION ESTIMATION ERRORS  
WITH C/S-1

--SIGNIFICANT VARIABILITY WAS OBSERVED IN MEAN PROPORTION ESTIMATION  
ERRORS BETWEEN ANALYST TEAMS

EFFECT OF DIFFERENT ANALYST TEAMS  
ON PERFORMANCE OF C/S-J

CORN: 1978

	TEAM #1	TEAM #2	TEAM #3
$\bar{e}$	3.8**	8.2**	4.3**
$S_e$	5.1	3.2	4.8
M.A.E.	5.0	8.2	5.8
R.M.E.	11.0	22.2	12.6
$\bar{P}$	34.7	37.0	34.1
n	12	9	9

SOYBEANS: 1978

	TEAM #1	TEAM #2	TEAM #3
$\bar{e}$		-8.1**	-5.0**
$S_e$		3.7	4.8
M.A.E.		8.1	5.0
R.M.E.		-28.1	-14.8
$\bar{P}$		28.8	33.8
n	12	9	9

ANALYSIS OF VARIANCE FOR  $\bar{e}$  INDICATES  
NO SIGNIFICANT DIFFERENCES BETWEEN  
TEAMS.

ANALYSIS OF VARIANCE FOR  $\bar{e}$  INDICATES  
SIGNIFICANT DIFFERENCES BETWEEN TEAMS.

EFFECT OF DIFFERENT ANALYST TEAMS  
ON PERFORMANCE OF C/S-1

SUMMER CROPS: 1972

	TEAM #1	TEAM #2	TEAM #3
$\bar{e}$	-4.3**	1.6	-0.2
$s_e$	5.1	5.5	7.5
M.A.E.	5.0	4.8	5.5
R.M.E.	-6.7	2.4	-0.3
$\bar{P}$	63.5	67.9	59.9
n	12	12	12

ANALYSIS OF VARIANCE FOR  $\bar{e}$  INDICATES  
SIGNIFICANT DIFFERENCES BETWEEN TEAMS.

CHARACTERISTICS OF MACHINE GENERATED FIELDS (BLOBS)  
FOR SEGMENTS PROCESSED TO CROP TYPE

**DEFINITION:** PURITY OF A TARGET IS DEFINED IN TERMS OF ITS "CORRECT" LABEL ACCORDING TO C/S-1 DECISION LOGIC, BASED ON ITS INTERIOR CROP-TYPE PROPORTIONS, USING GROUND OBSERVATION DATA:

**PURE TARGET:** "CORRECT" LABEL CONSISTS OF A SINGLE LETTER (EITHER C, S, OR O)

**MIXED TARGET:** "CORRECT" LABEL CONSISTS OF TWO OR THREE LETTERS (FOR EXAMPLE, CO, OR CSO, OR CCO)

**NOTE:** ALTHOUGH THE GROUND-DATA "CORRECT" LABEL DETERMINES WHETHER THE TARGET IS ACTUALLY "MIXED" OR "PURE", THE LABEL ASSIGNED TO IT BY THE ANALYST USING PROCESSED SATELLITE DATA MAY (CORRECTLY OR INCORRECTLY) BE EITHER A "PURE" LABEL OR A "MIXED" LABEL.

O PERFORMANCE OF THE BLOBBING ALGORITHM WAS CONSISTENT BETWEEN YEARS.

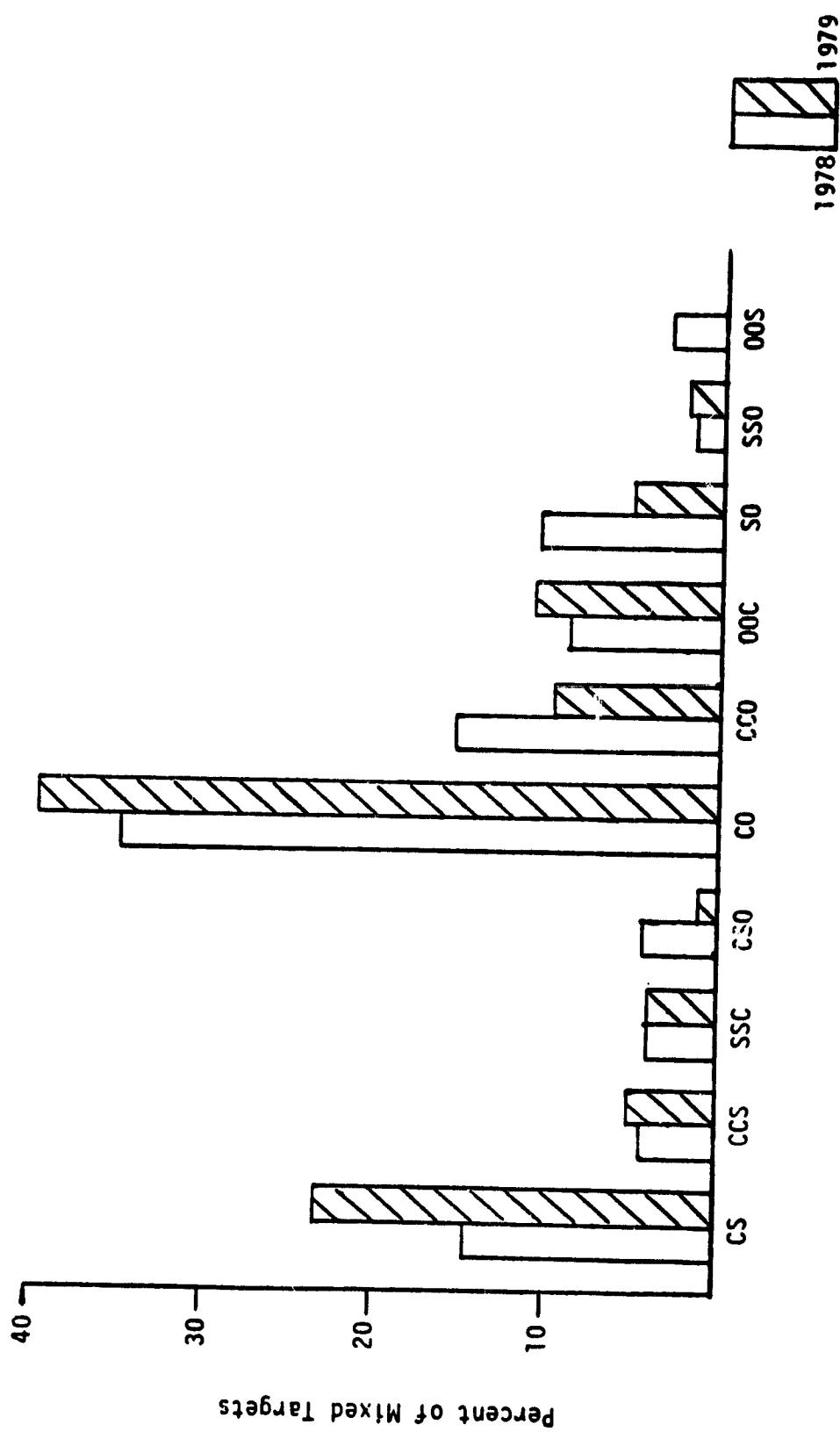
<u>SAMPLED TARGETS</u>	<u>1978</u>	<u>1979</u>
PURE (%)	86.5	83.8
MIXED (%)	13.4	11.2
TOTAL	3045	913

--CHARACTERISTICS OF MIXED TARGETS

	<u>1978</u>	<u>1979</u>
TWO CROP MIXTURES (%)	53.5	68.0
THREE CROP MIXTURES (%)	40.5	32.0
TOTAL	497	103

--MIXTURES BETWEEN CORN & OTHER CONSISTENT PROBLEM

FREQUENCY OF OCCURRENCE OF  
SPECIFIC CROP MIXTURES  
CROP YEARS 1978/1979



## TARGET LABELING PERFORMANCE

O LABELING PERFORMANCES FOR CROP YEARS 1973 AND 1979 WERE SIMILAR IN SOME WAYS, DIFFERENT IN OTHERS

### ---SIMILARITIES:

- + MOST TARGETS ARE LABELED AS PURE BY ANALYST-INTERPRETERS USING PROCESSED SATELLITE DATA:

		<u>1978</u>	<u>1979</u>
PURE	WHEN	PURE	97.8%
PURE	WHEN	MIXED	65.9%

\*USING PROCESSED SATELLITE DATA

\*\*BASED ON GROUND OBSERVATION DATA

- + TARGETS WHICH ARE PURE ACCORDING TO GROUND DATA ARE LIKELY TO BE LABELED CORRECTLY BY ANALYST-INTERPRETERS USING PROCESSED SATELLITE DATA:

<u>PURE TARGETS</u>	<u>1973</u>	<u>1979</u>
PROBABILITY OF CORRECT LABEL (PCL)	83.1%	30.6%
TOTAL NUMBER OF PURE TARGETS	2638	815

- + "OTHER" TARGETS ARE ABOUT 3-1/2 TIMES AS LIKELY TO BE CALLED CORN THAN TO BE CALLED SOYBEANS, IN 1973 AND IN 1979.

## TARGET LABELING PERFORMANCE (CONTINUED)

- + TARGETS WHICH ARE MIXED ACCORDING TO GROUND DATA ARE UNLIKELY TO BE LABELED AS MIXED, AND VERY UNLIKELY TO BE LABELED "CORRECTLY," BY ANALYST-INTERPRETERS USING PROCESSED SATELLITE DATA:

<u>MIXED TARGETS</u>	<u>1973</u>	<u>1979</u>
PROBABILITY OF BEING LABELED AS MIXED	36.1%	35.0%
PROBABILITY OF CORRECT LABEL (PCL)	29.6%	21.4%
TOTAL NUMBER OF MIXED TARGETS	407	103

- + HIGHER PROBABILITY OF IDENTIFYING A TARGET AS MIXED WHEN THREE OR MORE CROPS ARE WITHIN THE TARGET.

<u>(AI) WHEN (CORRECT LABEL)</u>	<u>1973</u>	<u>1979</u>
MIXED WHEN TWO-CROP MIXTURE	28.9%	31.4%
MIXED WHEN THREE-CROP MIXTURE	46.7%	42.4%

- + LABELING ACCURACIES FOR CORN AND OTHER MIXTURES GREATER THAN FOR SOYBEANS AND OTHER OR CORN AND SOYBEANS MIXTURES (PROBABILITY OF CORRECT LABEL):

<u>MIXTURE</u>	<u>1973</u>	<u>1979</u>
CORN & OTHER (PCL)	27.2%	30.6%
SOYBEANS & OTHER (PCL)	11.7%	14.3%
CORN & SOYBEANS (PCL)	12.1%	5.1%

--DIFFERENCES (SEE CHART OF LABELING ACCURACY PERFORMANCE FOR PURE TARGETS):

- + LABELING ACCURACIES FOR SOYBEANS TARGETS LOWER THAN FOR CORN OR OTHER IN 1978; HIGHER THAN FOR CORN OR OTHER IN 1973.
- + MORE SOYBEANS TARGETS CALLED OTHER THAN OTHER TARGETS CALLED SOYBEANS IN 1978; VERY FEW ERRORS OF EITHER TYPE IN 1979.
- + SLIGHTLY MORE SOYBEANS TARGETS CALLED CORN THAN CORN CALLED SOYBEANS IN 1978; NEARLY TWICE AS MANY CORN TARGETS CALLED SOYBEANS AS SOYBEANS CALLED CORN IN 1979.
- + MANY MORE OTHER TARGETS CALLED CORN THAN CORN TARGETS CALLED OTHER IN 1978; IN TERMS OF NUMBERS RATHER THAN PERCENTAGES OF RESPECTIVE CATEGORIES, SLIGHTLY OPPOSITE IN 1979.
- + SOYBEANS TARGETS TWICE AS LIKELY TO BE CALLED OTHER AS TO BE CALLED CORN IN 1978; 7-1/2 TIMES AS LIKELY TO BE CALLED CORN AS TO BE CALLED OTHER IN 1979.
- + CORN TARGETS 1-1/2 TIMES AS LIKELY TO BE CALLED OTHER AS TO BE CALLED SOYBEANS IN 1973; MORE THAN TWICE AS LIKELY TO BE CALLED SOYBEANS AS TO BE CALLED OTHER IN 1979.

LABELING ACCURACY PERFORMANCE FOR PURE TARGETS

1978

ANALYST LABELS\*

		C	S	O	MIXED	TOTAL
C	925	31	46	31	1033	
	89.5	3.0	4.5	3.0	--	
S	33	650	66	14	763	
	4.3	85.2	8.7	1.8	--	
GROUNDS TRUTH LABELS	0	62	17	749	14	842
	27.7%	7.4	2.0	89.0	1.7	--

\*USING  
PROCESSED SATELLITE DATA

\*\*BASED  
ON GROUND OBSERVATION DATA

1979

		C	S	O	MIXED	TOTAL
C	354	26	12	4	396	
	89.4	6.6	3.0	1.0	--	
S	15	237	2	4	258	
	5.8	91.9	0.8	1.6	--	
19.8%	0	10	3	147	1	161
	6.2	1.9	91.3	0.6	--	

2638

815

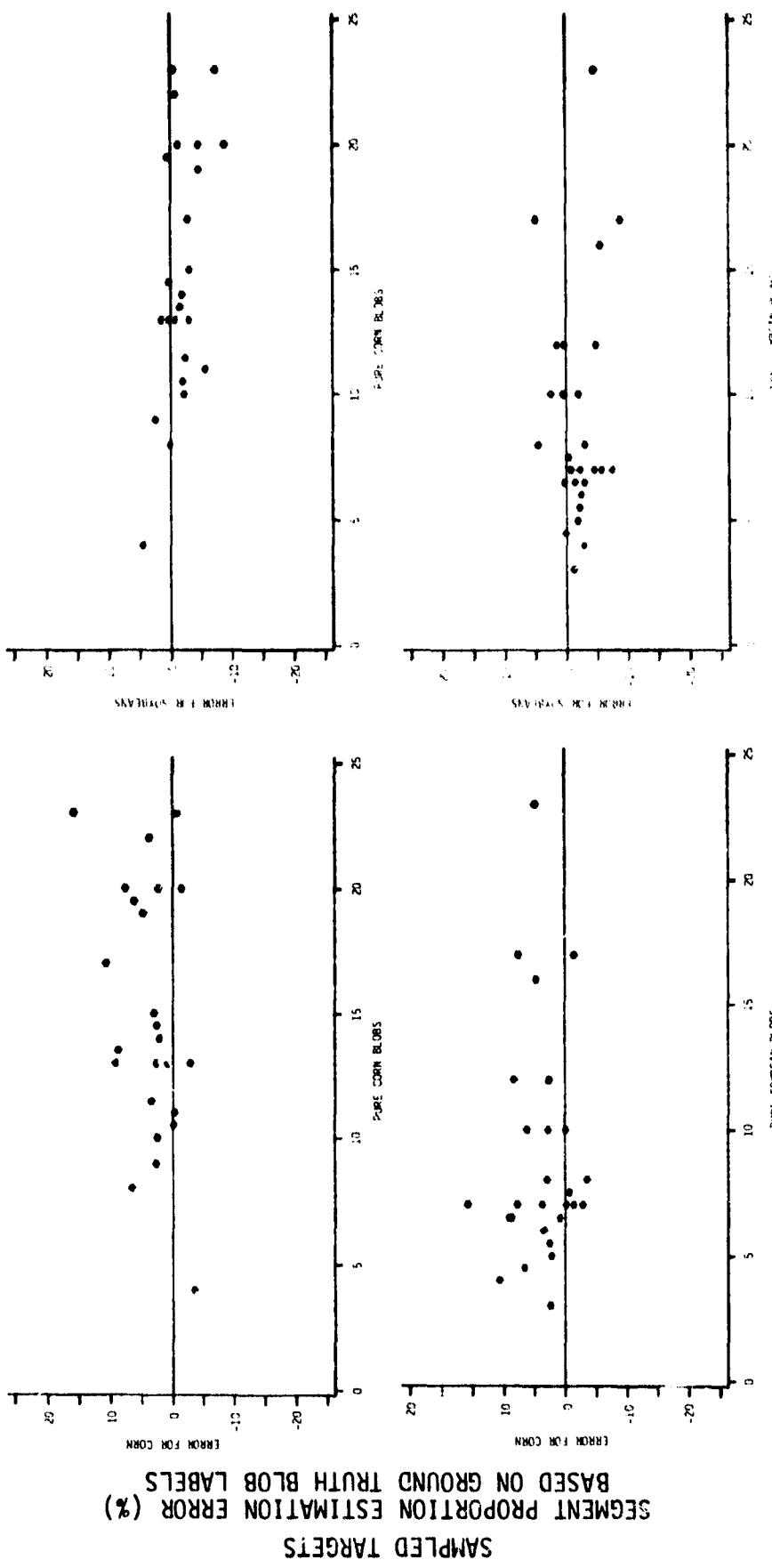
O RELATIONSHIP BETWEEN MEDIAN LABELING TARGET SIZE FOR PURE TARGETS AND PROPORTION ESTIMATION ERRORS:

--NO APPARENT DEPENDENCY WAS FOUND

--INDICATIONS WERE FOUND THAT PURE CORN TARGETS, PURE SOYBEANS TARGETS, AND PURE OTHER TARGETS ARE RANKED IN THAT ORDER FROM LARGEST TO SMALLEST IN TERMS OF MEAN NUMBER OF INTERIOR PIXELS

**RELATIONSHIP BETWEEN MEDIAN BLOB SIZE AND PROPORTION ESTIMATION ERROR**

NO APPARENT DEPENDENCY



**MEDIAN NUMBER OF INTERIOR PIXELS IN SAMPLED BLOBS WITH PURE GROUND TRUTH LABELS  
FOR EACH 1978 SEGMENT PROCESSING**

## **SUMMARY OF RESULTS**

**3.64**

**D. NORWOOD  
9/29/81**

## SUMMARY OF RESULTS

- C/S-1 ATTEMPTED TO ADDRESS SPECIFIC TECHNICAL PROBLEMS IDENTIFIED IN PREVIOUS EXPERIMENTS, WHILE MAINTAINING THE PROPORTION ESTIMATION ACCURACIES FOR CORN AND SOYBEANS OF THE PRECEDING TECHNOLOGIES.
  - FORMALLY ADDRESSED THE PROBLEM OF IDENTIFYING AND LABELING BOTH PURE AND MIXED TARGETS IN AN OBJECTIVE MANNER.
  - + DEFINITION OF FIELD-LIKE TARGETS (BLOBS)
  - + DEFINITION OF MIXED LABELS FOR MIXED TARGETS
- DEVELOPED STRATIFIED AREAL ESTIMATION SCHEME TO UTILIZE FIELD-LIKE TARGETS.

- C/S-1 AS A SUMMER CROP ESTIMATOR IS VERY ACCURATE IN TERMS OF MEAN ERROR, STANDARD DEVIATION, AND RELATIVE MEAN ERROR.
  - 1978: RELATIVE MEAN ERROR OF -1.5% WAS NOT STATISTICALLY SIGNIFICANT.
  - 1979: RELATIVE MEAN ERROR OF 1.8% WAS STATISTICALLY SIGNIFICANT BUT NOT SUBSTANTIAL.
- C/S-1 REPRESENTS A SUBSTANTIAL IMPROVEMENT IN ACCURACY AND PRECISION FOR 1978 OVER THE TY EXPLORATORY PROCEDURE (P.V.T.)
- + REDUCTION IN R.M.E. FROM -16.4% FOR P.V.T. TO -1.5% FOR C/S-1
  - + REDUCTION IN STANDARD DEVIATION FROM 9.7% FOR P.V.T. TO 5.5% FOR C/S-1

- RESULTS FOR C/S-1 FOR ESTIMATION OF CORN AND SOYBEANS VARIED WITH CROP YEAR AND CROP TYPE.

- CORN:

- + OVERESTIMATION OF 15.0% R.M.E. IN 1978
  - + INDICATIONS OF 6.0% OVERESTIMATION R.M.E. IN 1979

- SOYBEANS:

- + UNDERESTIMATION OF 16.7% R.M.E. IN 1978

- + INDICATIONS OF 3.0% UNDERESTIMATION R.M.E. IN 1979

- COMPARISON OF PROPORTION ESTIMATION PERFORMANCE OF C/S-1 AND P.V.T. FOR CORN AND SOYBEANS IN 1978.

- + CORN:

- OVERESTIMATION OF 15.0% R.M.E. FOR C/S-1
  - UNDERESTIMATION OF 7.7% R.M.E. FOR P.V.T.
  - C/S-1 HAD A 17% LOWER STANDARD DEVIATION.

- + SOYBEANS:

- UNDERESTIMATION OF 18.7% R.M.E. FOR C/S-1
  - UNDERESTIMATION OF 19.7% R.M.E. FOR P.V.T.
  - C/S-1 HAD A 34% LOWER STANDARD DEVIATION

- SIGNIFICANT VARIABILITY WAS OBSERVED IN MEAN PROPORTION ESTIMATION ERRORS BETWEEN ANALYST TEAMS FOR C/S-1, AS WELL AS FOR P.V.T.

O EFFECT ON C/S-1 PROPORTION ESTIMATION ERRORS OF DIFFERENT TARGET LABELING  
SOURCES: GROUND TRUTH, ANALYST, MACHINE

--SUMMER CROPS PROPORTION ERRORS:

- + NO SUBSTANTIAL CONTRIBUTION FROM EITHER THE PROPORTION ESTIMATION TECHNIQUE OF C/S-1 OR THE ANALYST LABELING ERRORS IN TERMS OF MEAN ERROR IN EITHER CROP YEAR.
- + BOTH SOURCES CONTRIBUTED TO THE STANDARD DEVIATION OF THE ERRORS IN 1978, BUT THE STANDARD DEVIATION IMPROVED SLIGHTLY WITH ANALYST LABELS IN 1979.
- + THE USE OF ANALYST LABELS RATHER THAN MACHINE LABELS TENDED TO IMPROVE THE ERRORS IN TERMS OF BOTH MEAN ERROR AND STANDARD DEVIATION:
  - SUBSTANTIALLY IN 1979
  - LESS SUBSTANTIALLY IN 1978

--SIMILAR EFFECTS FOR CORN AND SOYBEANS PROPORTION ERRORS DUE TO GROUND TRUTH AND ANALYST LABELS:

- + IN 1978, BOTH THE PROPORTION ESTIMATION TECHNIQUE OF C/S-1 AND THE ANALYST LABELING ERRORS CONTRIBUTED SUBSTANTIALLY TO THE OVERESTIMATION (UNDERESTIMATION) OF CORN (SOYBEANS), IN TERMS OF BOTH MEAN ERROR AND STANDARD DEVIATION OF ERRORS.
- + IN 1979, THE OVERESTIMATION (UNDERESTIMATION) OF CORN (SOYBEANS) WAS DUE MAINLY TO THE PROPORTION ESTIMATION TECHNIQUE OF THE PROCEDURE (MEAN ERRORS EVEN SEEMED TO IMPROVE SLIGHTLY WITH ANALYST LABELS), BUT BOTH FACTORS CONTRIBUTED TO THE STANDARD DEVIATION OF ERRORS FOR EACH CROP.

- DIFFERENT EFFECTS FOR CORN AND SOYBEANS PROPORTION ERRORS DUE TO ANALYST RATHER THAN MACHINE LABELS:
  - + CORN ERRORS WERE SUBSTANTIALLY IMPROVED IN TERMS OF BOTH MEAN ERROR AND STANDARD DEVIATION IN BOTH CROP YEARS.
  - + SOYBEANS ERRORS WERE NOT DISCERNIBLY IMPROVED IN TERMS OF MEAN ERROR OR STANDARD DEVIATION IN EITHER CROP YEAR.

● EFFECT OF TREATMENT OF UNSAMPLED PORTION OF THE SCENE: LITTLE BLOBS WEIGHTED VS. BIG BLOBS ONLY

- THE INITIAL ESTIMATES (B.B.O) ARE DERIVED FROM SAMPLES TAKEN FROM A BIASED PORTION OF THE SCENE (BIG BLOBS ONLY), AND ARE BIASED WITH RESPECT TO THE ENTIRE SCENE (EVIDENCE TO BE DISCUSSED BY M. METZLER OF ERIM).
- THE B.B.O. ESTIMATES, ALTHOUGH THEY ARE NOT THE FINAL C/S-1 ESTIMATES, ARE THE INITIAL ESTIMATES TO WHICH BIAS CORRECTIONS ARE APPLIED IN ORDER TO ARRIVE AT THE FINAL ESTIMATES (L.B.W.)
- WITH ANALYST LABELS AND WITH GROUND TRUTH LABELS, THE EFFECT OF THE BIAS CORRECTION IS TO LOWER THE ESTIMATES FOR CORN AND FOR SOYBEANS, AND THUS ALSO FOR SUMMER CROPS.
- + THE MAGNITUDE OF CORN OVERESTIMATION IS REDUCED, BUT REMAINS SUBSTANTIAL
- + THE ALREADY SUBSTANTIAL MAGNITUDE OF SOYBEANS UNDERESTIMATION IS INCREASED.
- + THE SUMMER CROP ERRORS REMAIN INSUBSTANTIAL
- + THE STANDARD DEVIATIONS OF ERRORS ARE NOT SIGNIFICANTLY CHANGED BY THE BIAS CORRECTION FOR ANY CROP CATEGORY IN EITHER YEAR.
- THE CONTRIBUTIONS TO THE BIASES INHERENT IN THE B.B.O. ESTIMATES AND THE BIASES OBSERVED IN THE L.B.W. ESTIMATES WILL BE DISCUSSED LATER IN THIS PRESENTATION BY M. METZLER OF ERIM.

## 0 TARGET LABELING PERFORMANCE

- IN TERMS OF NUMBERS OF TARGETS FOR WHICH THE ANALYST LABELS BASED ON PROCESSED SATELLITE DATA WERE CORRECT OR INCORRECT ACCORDING TO GROUND OBSERVATION DATA:
  - + ACCURACIES FOR GROUND-DATA PURE TARGETS WERE NEAR 90% IN BOTH CROP YEARS.
  - + ACCURACIES FOR GROUND-DATA MIXED TARGETS WERE NEAR 21% IN BOTH CROP YEARS.
  - + ONLY ABOUT 35% OF THE GROUND-DATA MIXED TARGETS WERE LABELED AS MIXED BY ANALYSTS USING PROCESSED SATELLITE DATA IN BOTH CROP YEARS (NUMBER OF GROUND-DATA MIXED TARGETS IN 1973 WAS 13% OF TOTAL NUMBER OF TARGETS; IN 1979, 11%)
  - + TARGETS WHICH ACCORDING TO GROUND DATA WERE "PURE OTHER" WERE ABOUT 3-1/2 TIMES AS LIKELY TO BE LABELED AS CORN THAN AS SOYBEANS IN BOTH CROP YEARS.
  - + DIFFERENCES BETWEEN CROP YEARS 1973 AND 1979 IN LABELING ACCURACIES, RATES OF COMMISSION ERRORS, OMISSION ERRORS, AND CONFUSION ERRORS FOR GROUND-DATA PURE TARGETS SEEM TO BE CONSISTENT WITH DIFFERENCES IN MEAN PROPORTION ESTIMATION ERRORS FOR CORN, SOYBEANS, AND OTHER BETWEEN YEARS.
- THE CONTRIBUTION OF LABELING ACCURACIES AND ERROR RATES TO PROPORTION ESTIMATION ERRORS IS COMPLICATED:
  - + BY THE FACT THAT TARGETS (BLOBS) VARY IN SIZE (TOTAL NUMBER OF PIXELS)
  - + BY THE FACT THAT MANY TARGETS ARE MIXED ACCORDING TO GROUND DATA.
  - + BY THE FACT THAT TARGET LABELS SEEK TO APPROXIMATE THE VARYING CROP PROPORTIONS IN TARGET INTERIORS WITH DISCRETE PROPORTIONS OF 0, 1/3, 1/2, 2/3, 1

- + BY THE POSSIBILITY OF DIFFERENT LABELING ACCURACIES AND ERROR RATES IN DIFFERENT CROP GROUP STRATA.
- + BY THE EFFECT OF THE TREATMENT OF THE UNSAMPLED PORTION OF THE SCENE (LITTLE BLOBS)

--THE CONTRIBUTIONS OF LABELING ERRORS TO PROPORTION ESTIMATION ERRORS WILL BE DISCUSSED BY M. METZLER OF ERIM LATER IN THIS PRESENTATION.

- RELATIONSHIP BETWEEN MEDIAN LABELING TARGET SIZE FOR PURE TARGETS AND PROPORTION ESTIMATION ERRORS:

- NO APPARENT DEPENDENCY WAS FOUND.
  - INDICATIONS WERE FOUND THAT PURE CORN TARGETS, PURE SOYBEANS TARGETS, AND PURE OTHER TARGETS ARE RANKED IN THAT ORDER FROM LARGEST TO SMALLEST IN TERMS OF MEDIAN NUMBER OF INTERIOR PIXELS.

FY81 U.S. CORN AND SOYBEAN PILOT EXPERIMENT

Technical Conclusions and Recommendations Summary

- o The CS1 procedure has exhibited very accurate and precise acreage estimation at the summer crop versus non-summer crop level, and high levels of processability.
- o The CS1 corn and soybean estimation errors have low variance, but the accuracies vary from year to year and between analyst teams.
- o Specific issues/recommendations that should be addressed are:
  - + Continue to automate the proportion estimation procedure (CS1A) to improve efficiency and reduce analyst subjectivity.
  - + Error sources in CS1 that have been identified are:
    - oo Mixed targets (blobs) are more numerous than desired (defeats objective of labeling homogeneous fields).
    - oo Accuracy in analyst recognition and labeling mixed blobs is very low.
    - oo A potential for bias exists due to various causes. The correction to account for the bias in the unsampled portion of the scene is inadequate.
    - oo There are labeling logic deficiencies for double cropping, treatment of mixed targets and year effects (such as crop stress, and field preparation).
  - + These error sources have been partially addressed by CS1A, but the effect of these modifications on the procedure have not been fully evaluated. Therefore, in order to evaluate these and to understand remaining error sources, the following needs to be done:
    - oo Component testing now underway should be completed.
    - oo Err or characterization of CS1/CS1A results should be pursued.
- o Testing and evaluation of alternative technology should continue for integration into the FY82 U.S. Corn and Soybean Pilot Experiment.

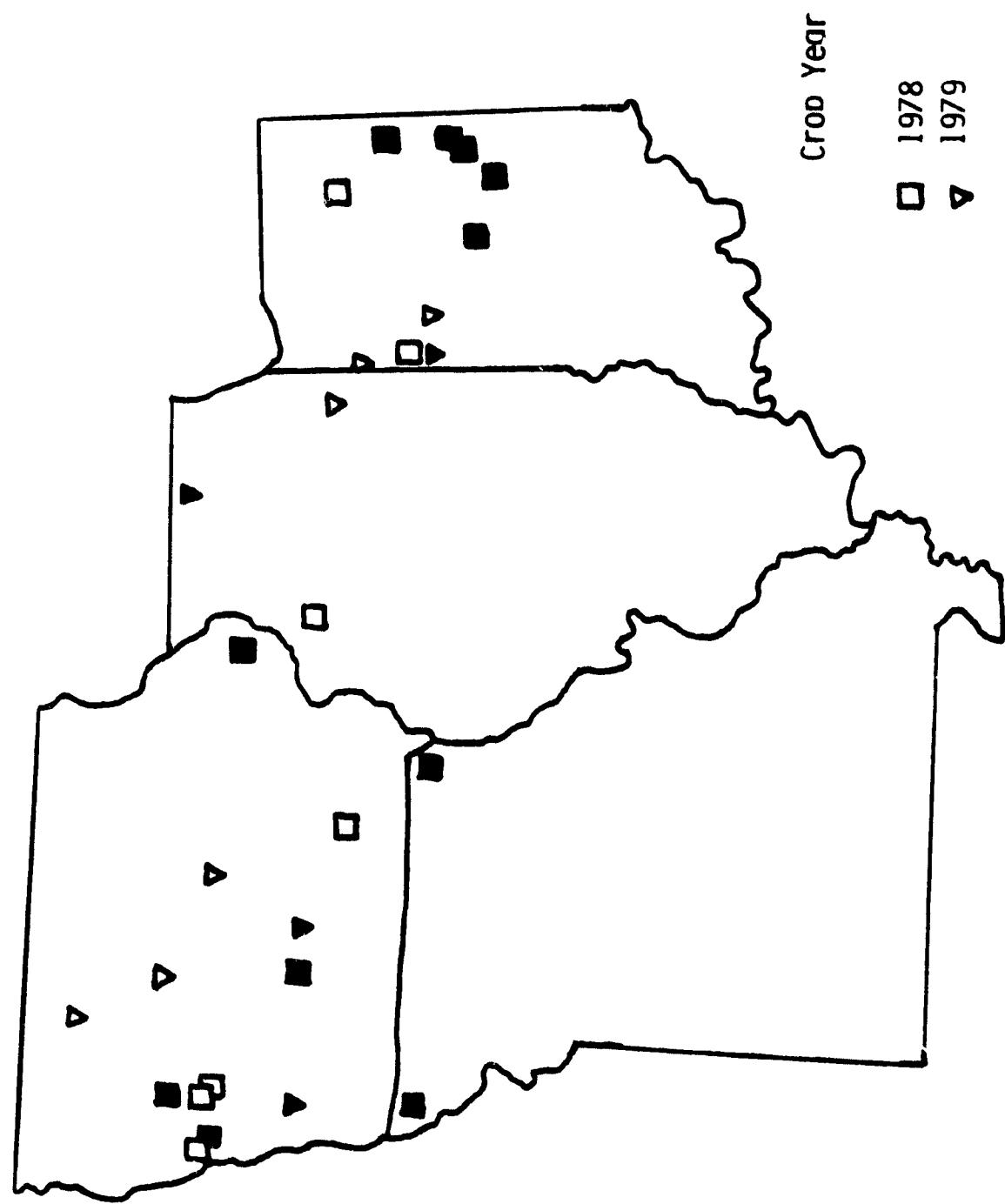
# **SENSITIVITY EVALUATIONS**

M. METZLER  
9/29/81

An intensive analysis of 11 segments from crop year 1978 and an additional 4 segments from crop year 1979 was undertaken to evaluate the performance of individual procedure subcomponents to determine key sources of error.

## KEY QUESTIONS ADDRESSED

- Which Subcomponents Caused Error?
- Why Was No Variance Reduction Seen Between C/S-1 and PVT with GT Labels?



## OVERALL SUMMARY OF ANALYSES

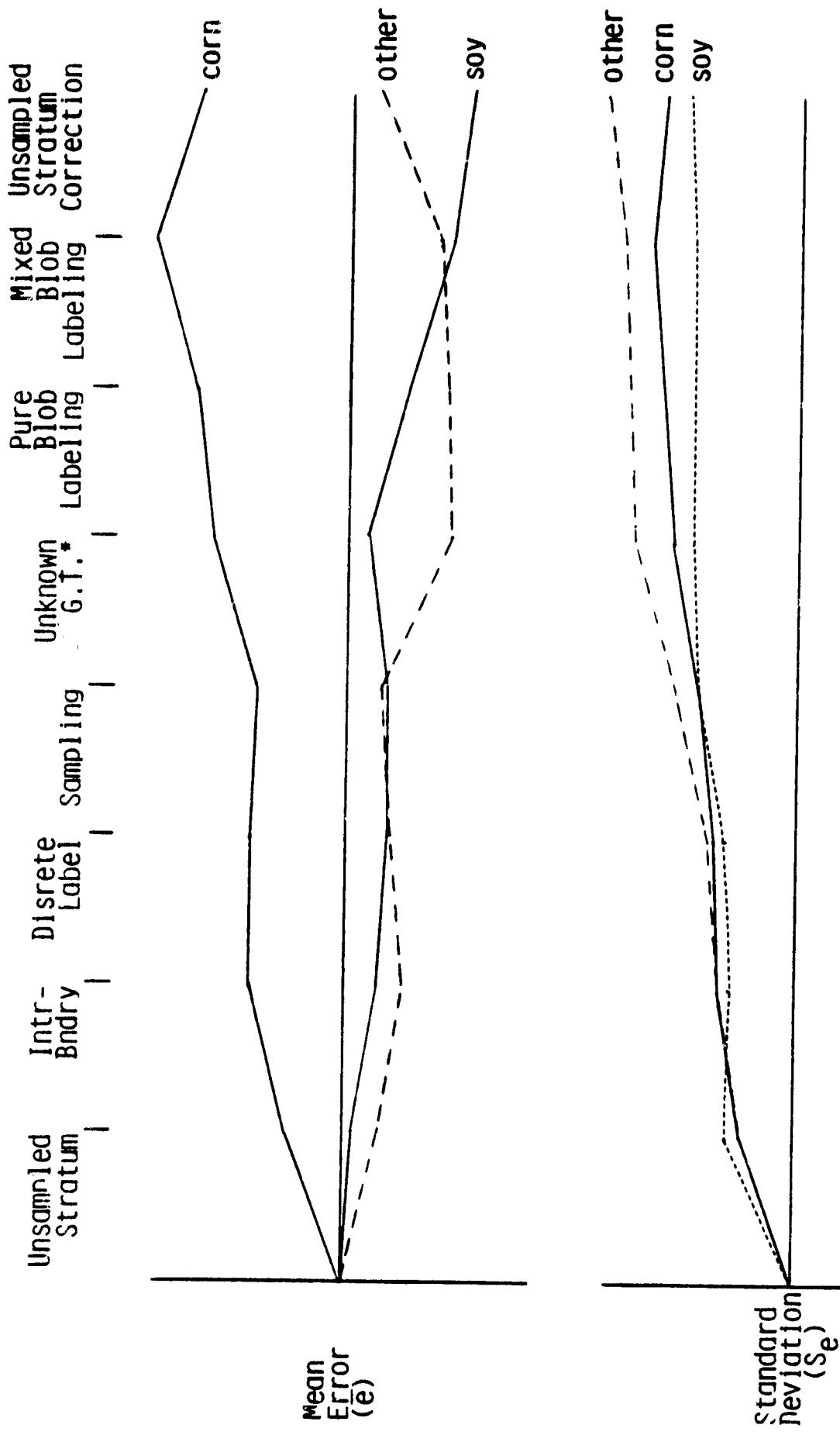
### SOURCES OF ERROR

- Labeling Performance
  - Accounts for approximately 70% of soybean estimation error, 40% of corn error
  - Labeling of pure targets accounts for less than one-half of the total labeling error
    - labeling inconsistencies and misdetection of crops with two vegetative phases predominant
    - small targets were more error prone
  - Labeling of mixed targets accounts for most of the estimation error attributable to labeling
    - only 10% of mixed targets were detected
    - inappropriate acquisition selection was a key factor for the presence of mixed targets
- Machine Performance
  - Target definition
    - about 22% of all targets were mixed (less than 5/6 pure)
    - a tendency to favor corn in assigning edges was detected
  - Machine processing
    - unsampled stratum correction only partially corrected the error for corn and other, and increased soy error
    - most of the variance in the estimates was attributable to the machine treatment of little blobs

## BREAKDOWN OF ERROR SOURCES

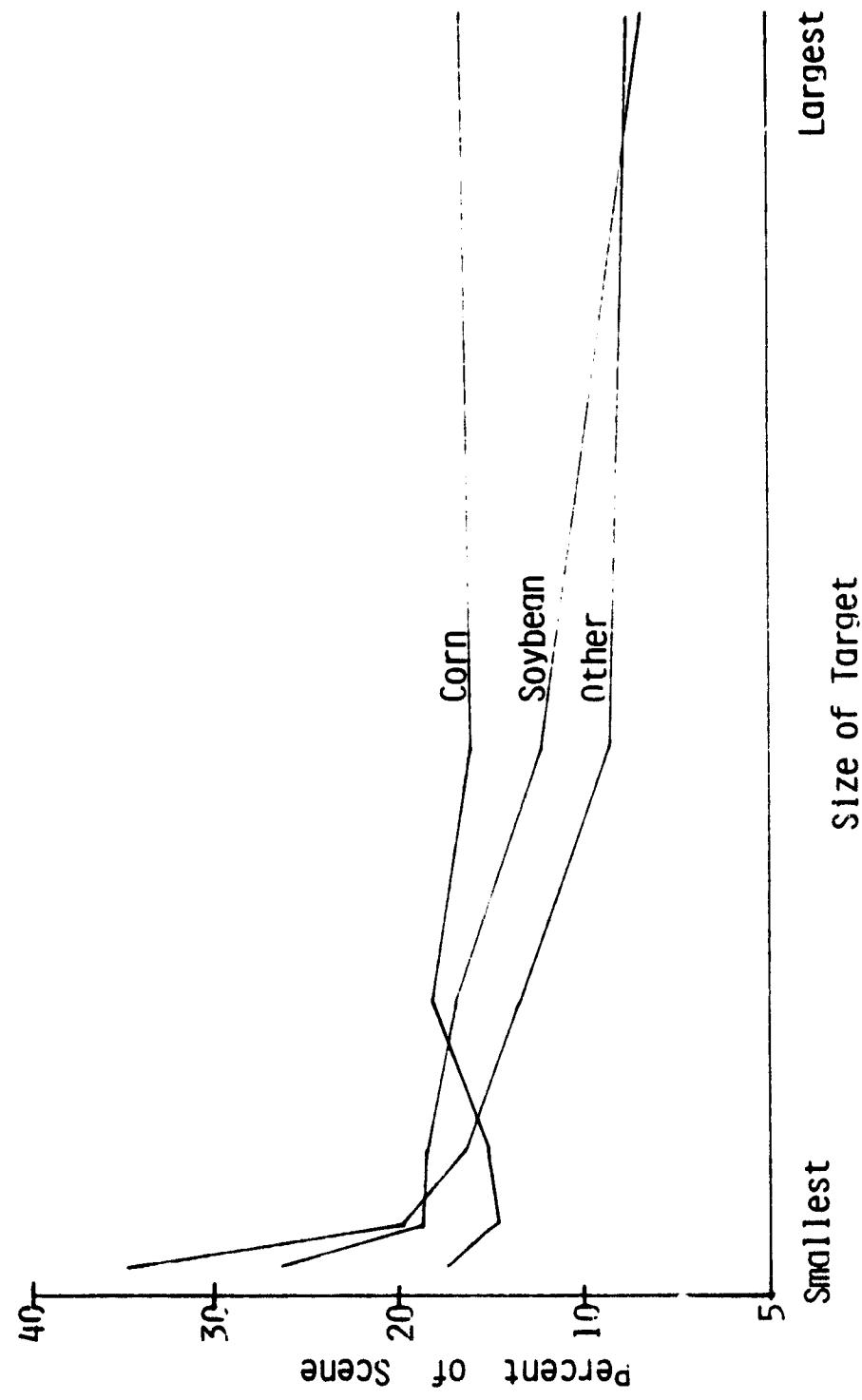
<u>Key</u>	<u>Subcomponent</u>	<u>Component</u>
P <sub>1</sub>	Unsampled Stratum (little blobs)	Machine
P <sub>2</sub>	Interior → Boundary Label Extension	Machine
P <sub>3</sub>	Discrete Label for Imperfectly Pure Targets	Machine
P <sub>4</sub>	Sampling	Machine
P <sub>5</sub>	GT Uncertainty	Ground Truth
P <sub>6</sub>	Labeling Purposes	Labeling
P <sub>7</sub>	Labeling Mixed	Machine
P <sub>8</sub>	Correction for Unsampled Stratum	Machine

PROGRESSIVE CONTRIBUTION TO ERROR BY SUBCOMPONENT



\*approximation based on assuming analyst labels of unknowns correct

RELATIONSHIP BETWEEN CROP TYPE AND TARGET SIZE



3.82

## EFFECT OF BLOB PURITY ON CROP PROPORTION ESTIMATES

% of Total Error  
Attributable to  
Labeling

Corn	
	>5/6 Pure
	<u>5/6 Pure</u>
	<5/6 Pure
Soy	
	>5/6 Pure
	<u>5/6 Pure</u>
	<5/6 Pure
Other	
	>5/6 Pure
	<u>5/6 Pure</u>
	<5/6 Pure

78.07% of sample in blobs  $\geq 5/6$  pure

21.94% of sample in blobs  $< 5/6$  pure

- Only Blobs with Known Ground Truth Considered
- Analysis of 11 Segments

## LABELING ACCURACY

BLOBS  $\geq$  5/6 PureWeighted

Label		
C	S	0
C/	95.86	0.39
S/	4.13	87.59
0/	6.95	0.84
GT		92.2

Unweighted

Label		
C	S	0
C/	91.42	0.61
S/	4.49	81.97
0/	7.98	1.24
GT		90.78

RANK OF PROCEDURE SUBCOMPONENTS CONTRIBUTION TO OVERALL BIAS AND VARIANCE

Contributors to Bias				Contributors to Variance			
<u>Corn</u>	<u>Soy</u>	<u>Other</u>	<u>Corn</u>	<u>Soy</u>	<u>Other</u>	<u>Corn</u>	<u>Soy</u>
Labeling	Labeling	Labeling	Unsampled Stratum	Unsampled Stratum	Unsampled Stratum	Unsampled Stratum	Unsampled Stratum
Extending Interior to Boundary	Unsampled Stratum	Unsampled Stratum	Labeling	Sampling	Sampling	Sampling	Sampling
Unsampled Stratum	Extending Interior to Boundary	Extending Interior to Boundary	Extending Interior to Boundary	Labeling	Labeling	Extending Interior to Boundary	Extending Interior to Boundary

## **4.0 PILOT EXPERIMENT - 1980 DATA PROCESSING**

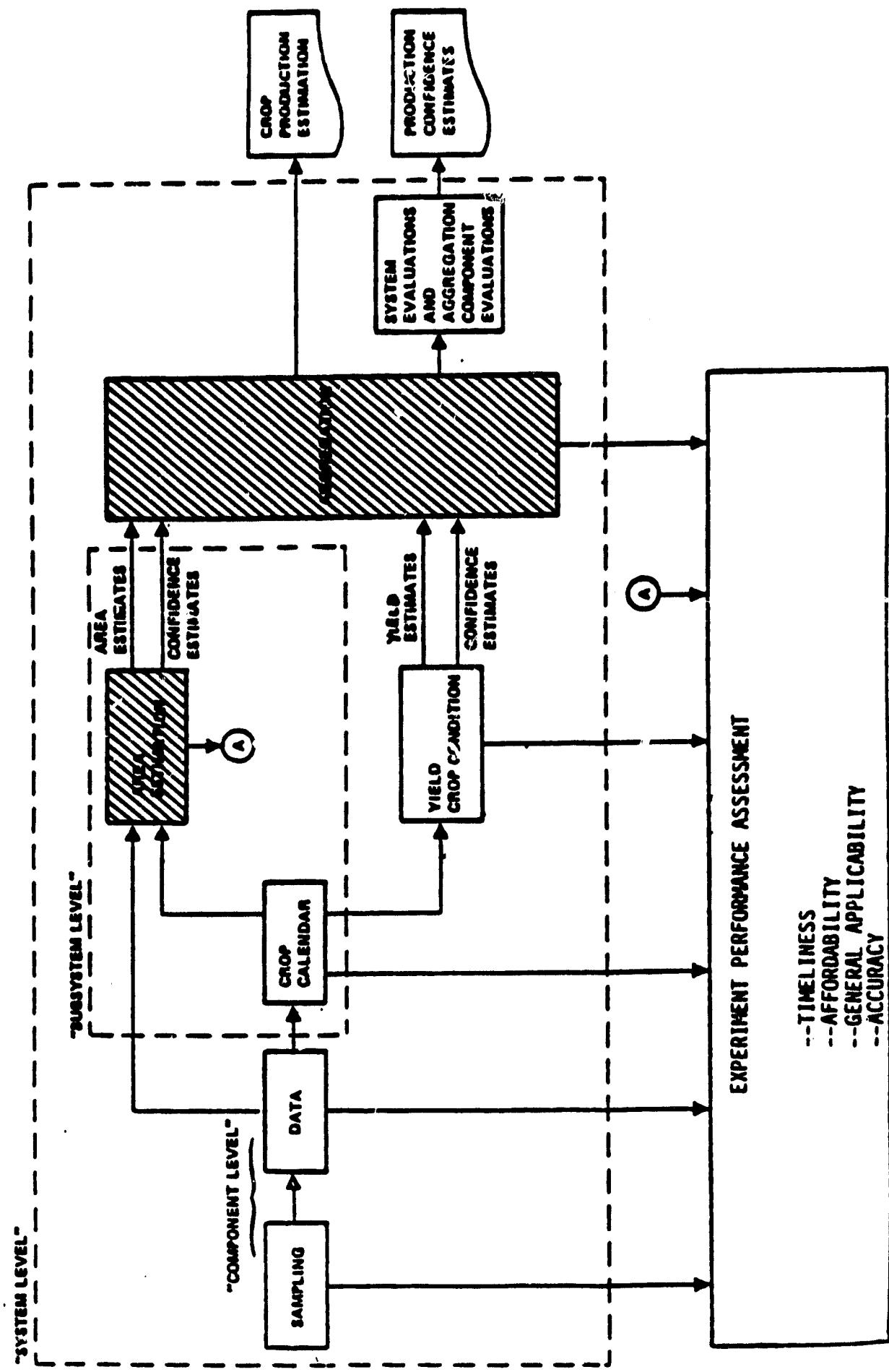
# OVERVIEW

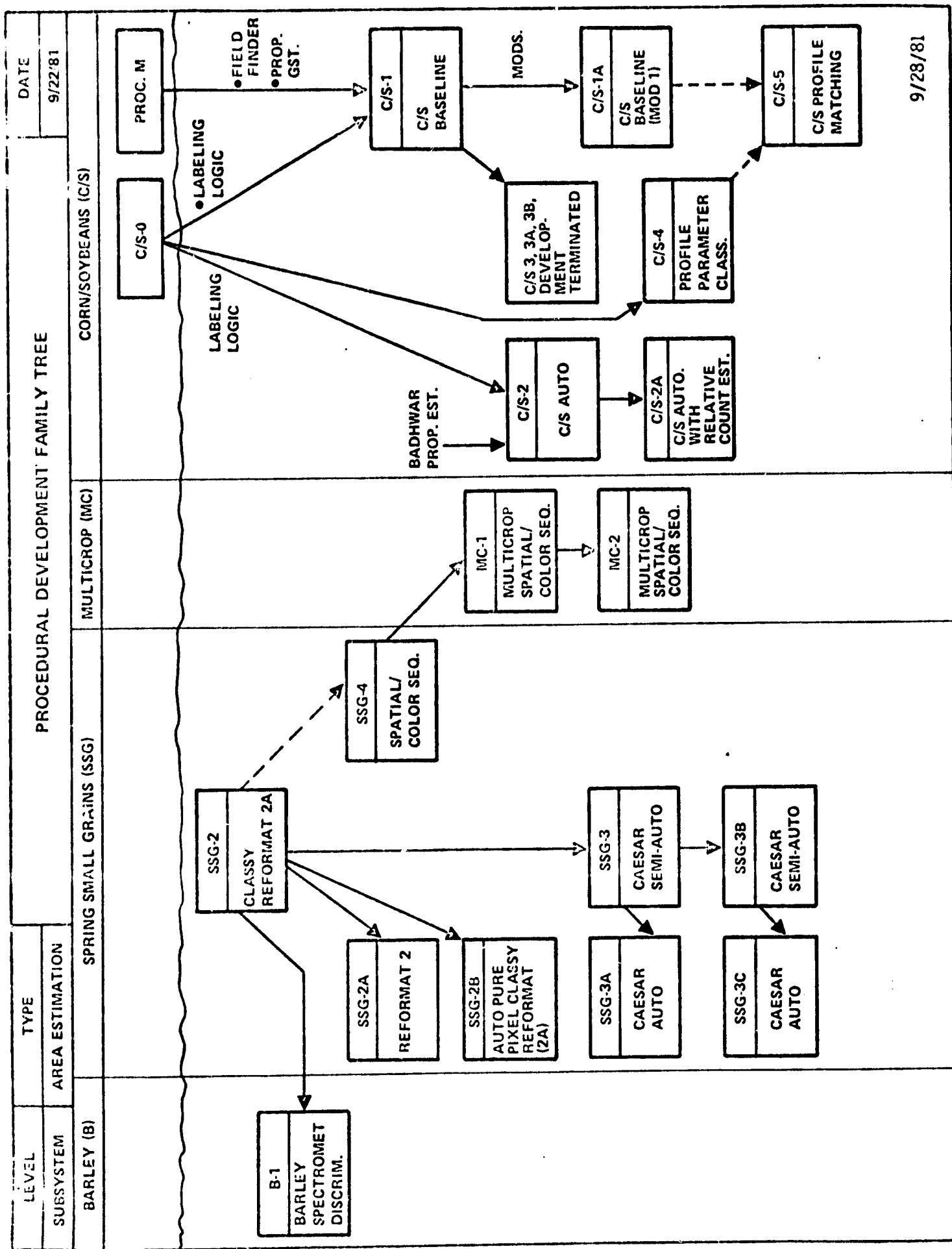
R. CICONE  
9/29/81

## SUMMARY

- Understanding Gained in the Evaluation of C/S-1 with 1978-79 Data has Led to the Development of C/S-1A that is Expected to Show Substantial Improvement in Accuracy Performance, with Improved Efficiency and Objectivity
- On-going Research and Development Efforts in SR and FCPF have Resulted in Alternative Area Estimation Procedures that are Candidates for Pilot or Laboratory Testing
- Validation Testing of Subcomponents and Shakedown Testing of Subsystems are Designed and Underway

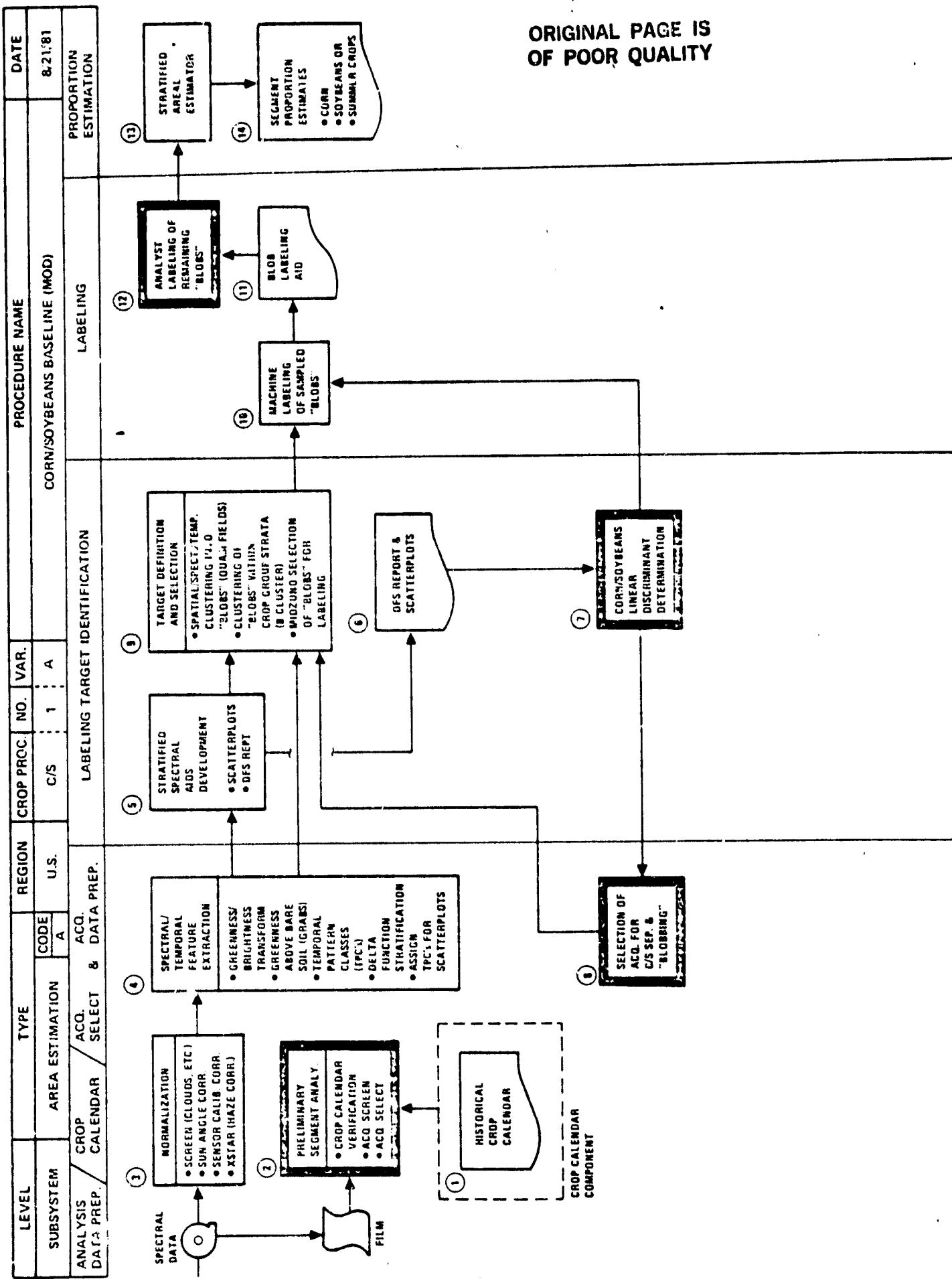
## SCOPE OF PILOT EXPERIMENT





## **DESCRIPTION OF CSIA**

J. COERMELLER  
9/29/81



LEVEL	TYPE	TYPE CODE	REGION	CROP PROC.	NO.	VAR.	PROCEDURE NAME	DATE
SUBSYSTEM	AREA ESTIMATION	A	U.S.	C:S	1	A	CORN/SOYBEANS BASELINE (MOD1)	8/21/81

- ORIGINAL PAGE IS  
OF POOR QUALITY
- (1) Historical crop stage data at lowest possible geopolitical level. Development stage model output at segment level. All possible crops.
  - (2) Manual image screen to delete excessive cloud cover and bad data and manually select candidate acquisitions based on crop calendar and imagery data in an interactive analysis.
  - (3) Screen algorithm for cloud identification. Sensor calibration, Sun-angle correction, and XSTAR haze correction.
  - (4) Temporal pattern class (TPC) features extracted in transformed brightness/G R ABS space for each pixel. Auto stratification of TPC into major crop groups for delta function stratification. Auto selection of TPC for blob labeling spectral aids (scatterplots).
  - (5) Stratified spectral aids development (generation of DFS report and scatterplots).
  - (6) Delta function stratification (DFS) report for major crop groups (summer crops).
  - (7) Manual determination of corn/soybean discriminant line.
  - (8) Manual determination of acquisition with best corn/soybean separation. Selection of acquisition subset for determining field-like patterns (blobs).
  - (9) Target definition through clustering into 'blobs'. Two groups formed based on "blob" size. Stratification of big blobs by crop group. "Blobs" selected for labeling based on proportional sampling of stratum size.
  - (10) Preliminary labeling of sampled "blobs" by machine.
  - (11) Spectral labeling aids and PFC overlay for selected blobs.
  - (12) Manual final labeling of remaining blobs and indication of confidence in label.
  - (13) Weighted aggregation of blob labels (large blobs).
  - (14) Segment proportion estimate by extension labeled blobs to unsampled (little) blobs and aggregating stratum providing estimates of corn/soybeans or summer crops.

## WHY C/S-1A?

### Weakness in C/S-1

#### Labeling Performance

1. Inconsistent labeling of pure targets
2. Misdetection of crops with two vegetative phases
3. Few mixed targets detected
4. Poor labeling performance on mixed blobs
5. DFS assignment tedious and error prone

#### Machine Performance

1. Target definition
2. Biased treatment of unsampled stratum

### Modification for C/S-1A

	<u>Evaluated</u>
1. Machine labels "classic" targets, partially labels remaining targets	x
2. Labeling logic refined, examples given	
3. Machine identifies potentially mixed blobs	x
4. Label selected pixels from mixed blob, not blob mean	
5. Automated DFS	x

## **MODIFICATIONS TO C/S-1**

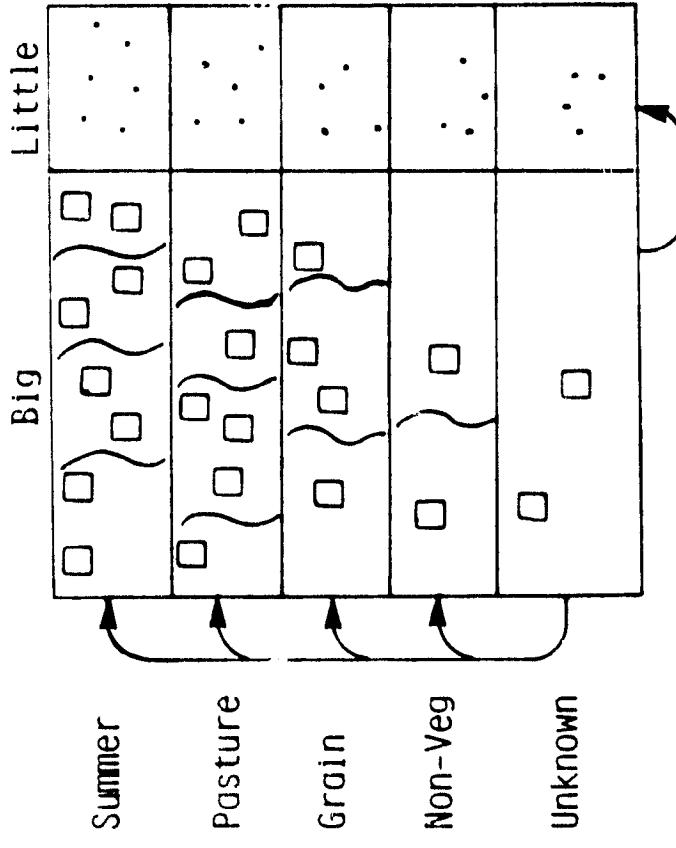
<u>What</u>	<u>Who</u>	<u>Why</u>
Acquisition Selection Criteria Tightened	Analyst	Accuracy, Objectivity
DFS Automated	Analyst/Machine	Efficiency, Accuracy, Objectivity
Maximum GRABS Used for Discriminant	Analyst	Accuracy
Acquisition by Acquisition Blobbing	Machine	Accuracy
Automatic Mixture Detection	Machine	Accuracy, Efficiency
Automatic Labeling of "Classic" Targets	Machine	Efficiency, Accuracy, Objectivity
Streamlined Labeling Logic	Analyst	Accuracy, Efficiency
Little Blobs Assigned to Clusters	Machine	Accuracy

## UNSAMPLED STRATUM

- Big Blobs in Known (Summer, Grain, Pasture, Non-Vegetated) Strata Clustered
- Unsampled Blobs (All Little Blobs and "Unknown" Big Blobs) Assigned to Big Blob Clusters, If Possible
- Cluster Proportions Weighted by All Blobs Within Cluster When Aggregated to Form Stratum and Segment Estimates

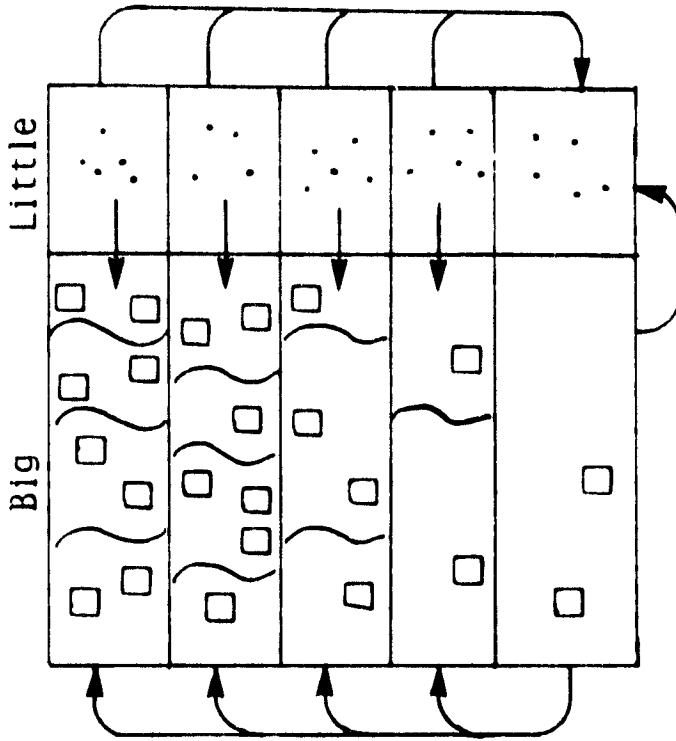
## TREATMENT OF UNSAMPLED STRATUM

C/S-1



Little blobs given same proportion as their DFS.

C/S-1A



Little blobs given same proportion as the cluster to which they are assigned.

PROPORTION ESTIMATION ERROR

39 PROCESSINGS, ANALYST LABELS  
1978, 1979 Crop Years

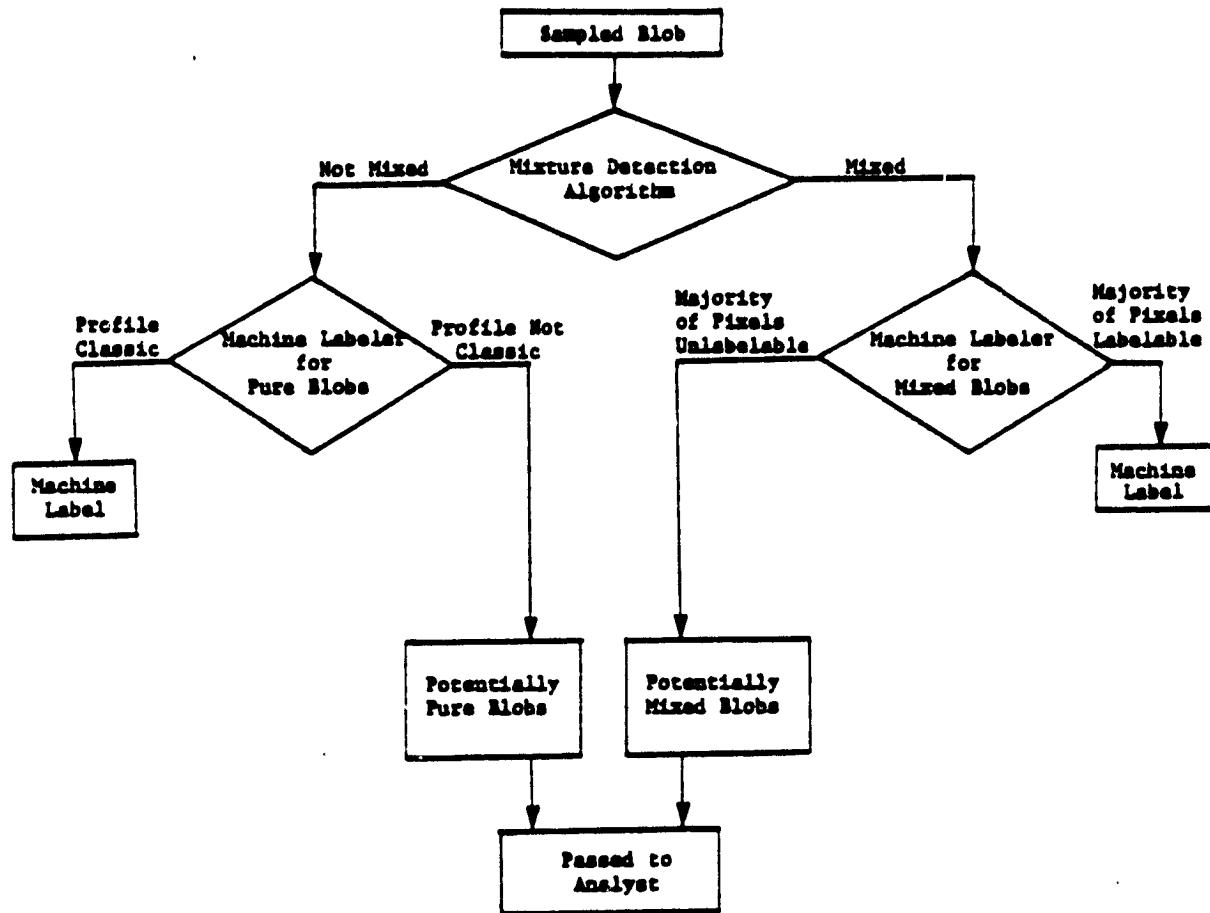
	Big Blobs Only	C/S-1	C/S-1A
	Correction	Correction	Correction
Corn	+6.11	+4.90	+3.17
Soy	-3.83	-4.46	-3.23
Other	-2.28	-0.45	+0.06

## IMPROVED TARGET DEFINITION (~ 9 SEGMENTS)

- Target Definition Improved by Two Modifications
  - Blob acquisition selection guidelines tightened
    - Blob algorithm modified
- Target Definition Significantly Improved
  - Average blob purity went from 87% to 94%
  - Number of mixed blobs reduced by 37%

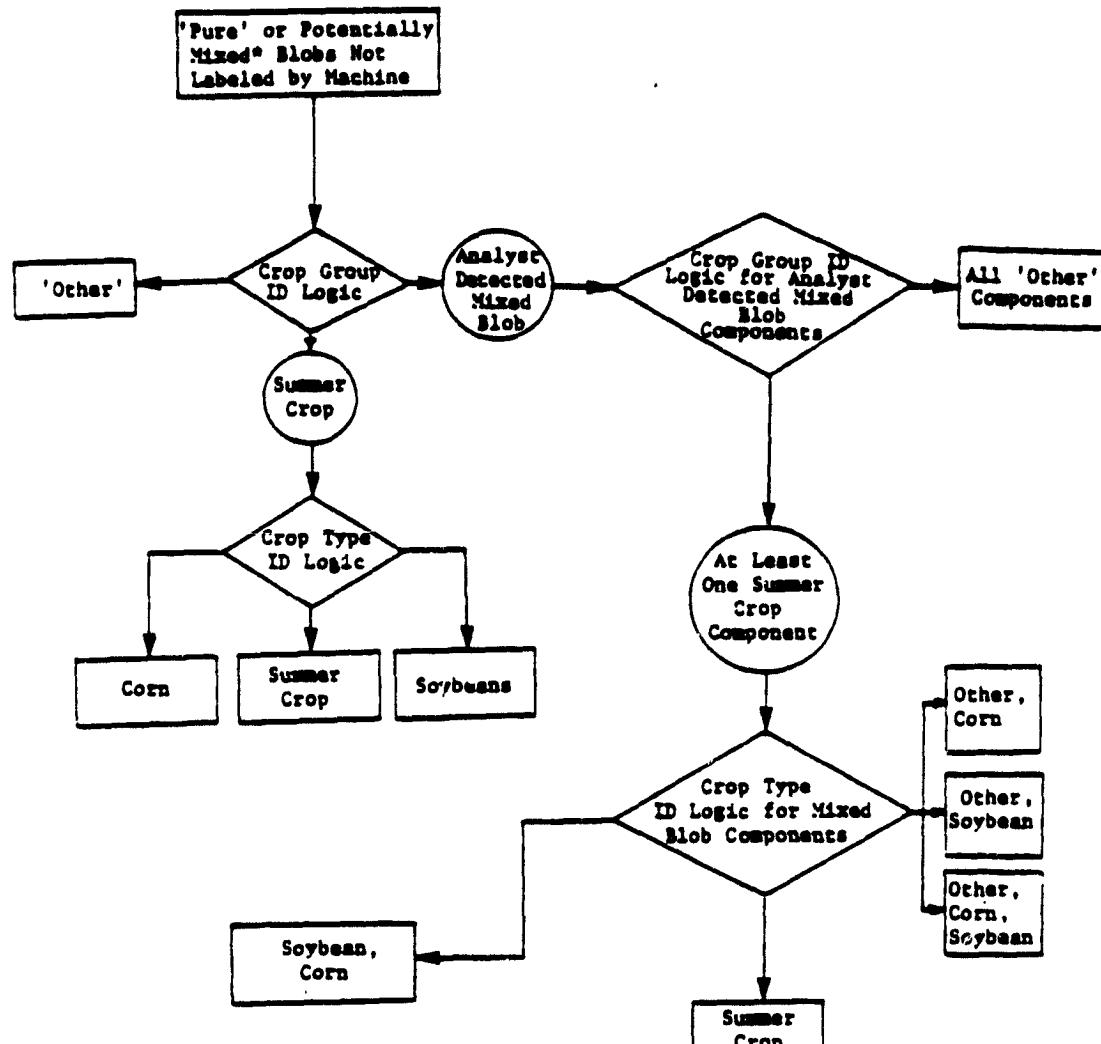
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C/S-1A LABELING STRATEGY



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## ANALYST LABELING STRATEGY



\*Pixel statistics are substituted for blob mean statistics  
in the analysis of machine detected potentially mixed blobs.

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## MIXED BLOB DETECTION

- Machine Examines Within-blob GRABS variance for key acquisitions
- Blob Flagged As "Probable Mixed" If Variance Above Threshold
- Analyst Labels 3 Pixels Randomly Selected from Blob Interior
- Correctly Flags Approximately 50% of the Mixed Blobs (< 2/3 Pure)
- Approximately 1/3 of the Flagged Blobs are Actually Mixed
  - Analyst may still assign pure labels to pure blobs which are flagged

## AUTOMATIC LABELER

- Labels "Classic" Corn, Soy, and Other Targets
- Follows C/S-1A Labeling Logic to Point Where
  - Target is labeled
  - Subjective question is encountered
- Informs Analyst Where to Continue With Labeling Logic if Target Was Not Labeled
- Attempts to Label Mixed Targets Pixel by Pixel
- Labeling Accuracy on Pure ( $\geq 5/6$  Single Class)
  - 96% for corn
  - 96% for soy
  - 98% for other

## SUMMARY OF C/S-1A STATUS

- C/S-1A Has Been Developed and Delivered
- Major Sources of Error in C/S-1 are Addressed
- Component Level Evaluations Indicate that Substantial Improvements May Be Achieved
- Shakedown Currently In Progress will Determine End-to-End Improvements

## **ALTERNATIVE PROCEDURES**

R. CICONE  
9/29/81

## SUMMARY

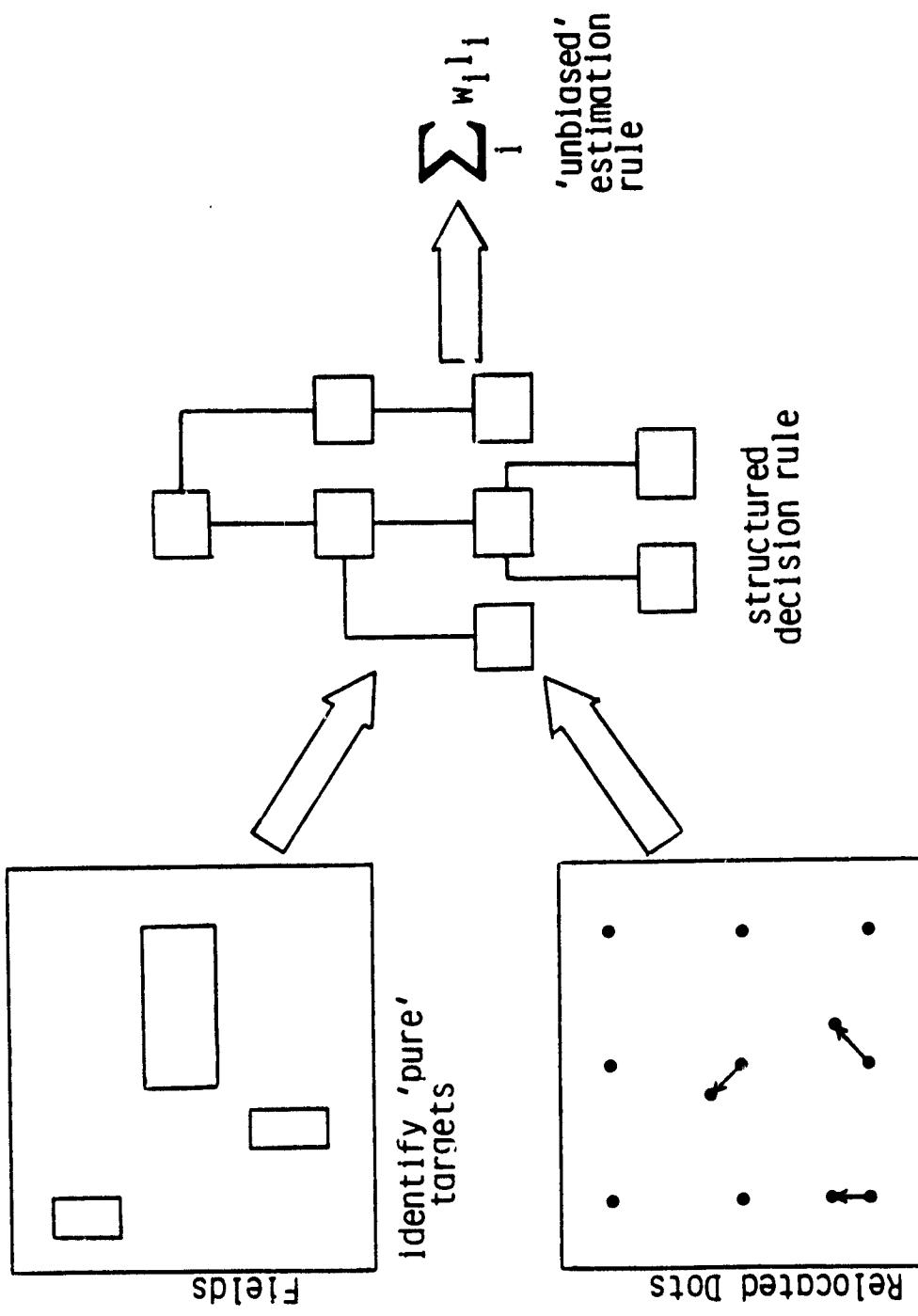
- Alternative Area Estimation Strategies are Available for Pilot and Exploratory Testing
- These Strategies Approach Aspects of the Area Estimation Problem in Unique Ways that, Once Evaluated, will Provide Needed Insight to Direct the Development of Crop Inventory Technology in Foreign Countries
- The Potential of Enhancing These At-Harvest Based Technologies to Efficient, Early Season Technologies will be a Key Concern

## CANDIDATE TECHNOLOGIES FOR PILOT

- ✓ C/S-1A      Modified Baseline      Stratified Areal Estimation,  
                    Objective Labeling of Field Like  
                    Targets
  - ✓ C/S-4      Badhwar/Magnus      Profile Feature Technology with  
                    Linear Rule Classification
  - + MC-2      Cate/Dennis Spatial  
                    Color Sequence      'Color' Bin Matching with Bias  
                    Correction for Planting Date  
                    Variation
  - + C/S-2A      Wade      Objective Labeling of Relocated  
                    Dots with Relative Count  
                    Estimator
- ✓ candidates for aggregation level evaluation
- + candidates for exploratory evaluation

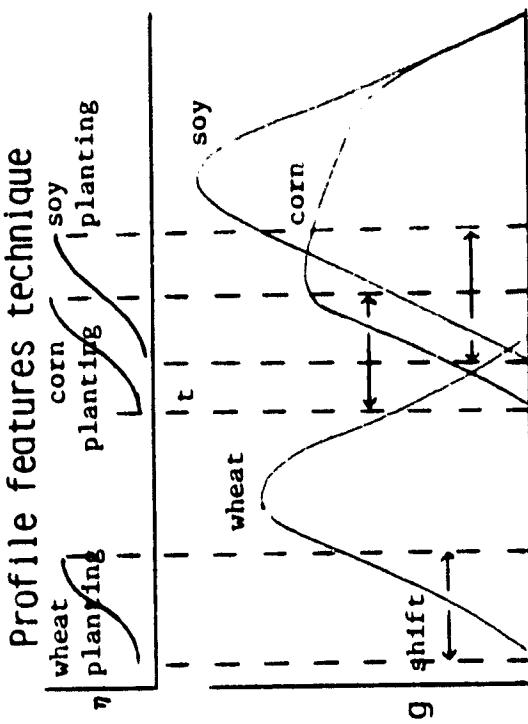
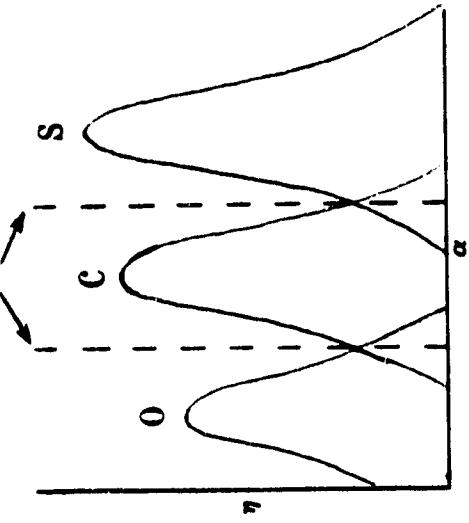
OBJECTIVE LABELING BASED METHODS

CS-1A, CS-2A

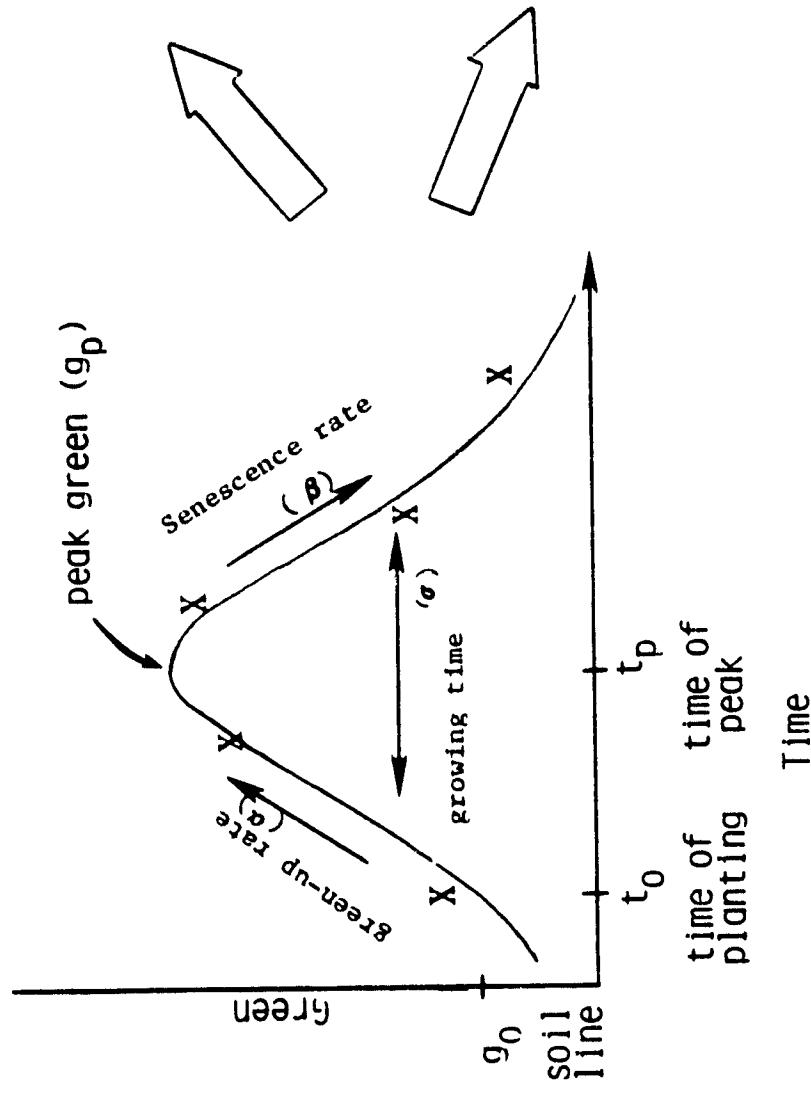


PROFILE BASED METHODS  
C/S-4, (C/S-5)

discriminant boundaries



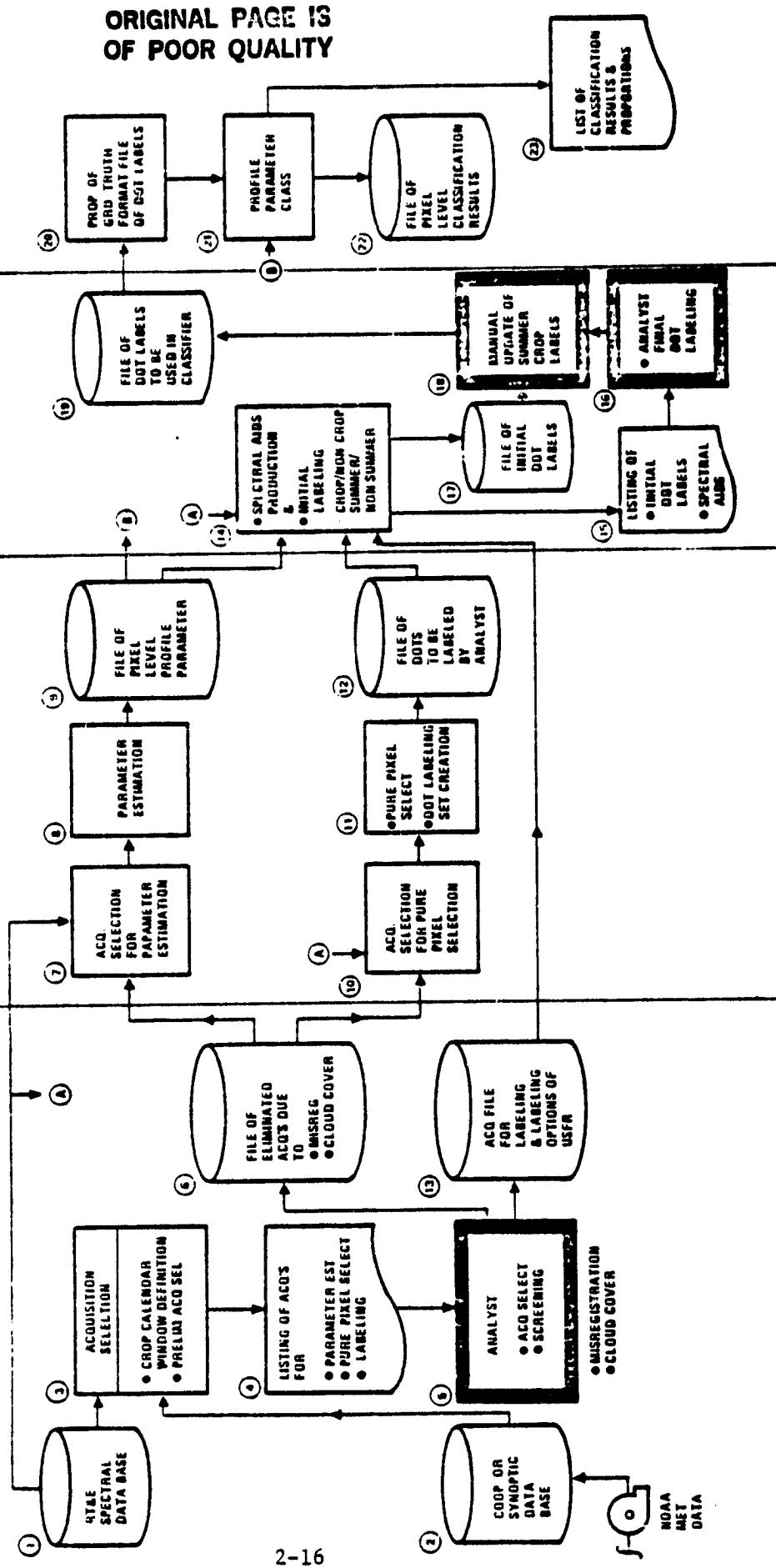
Profile matching



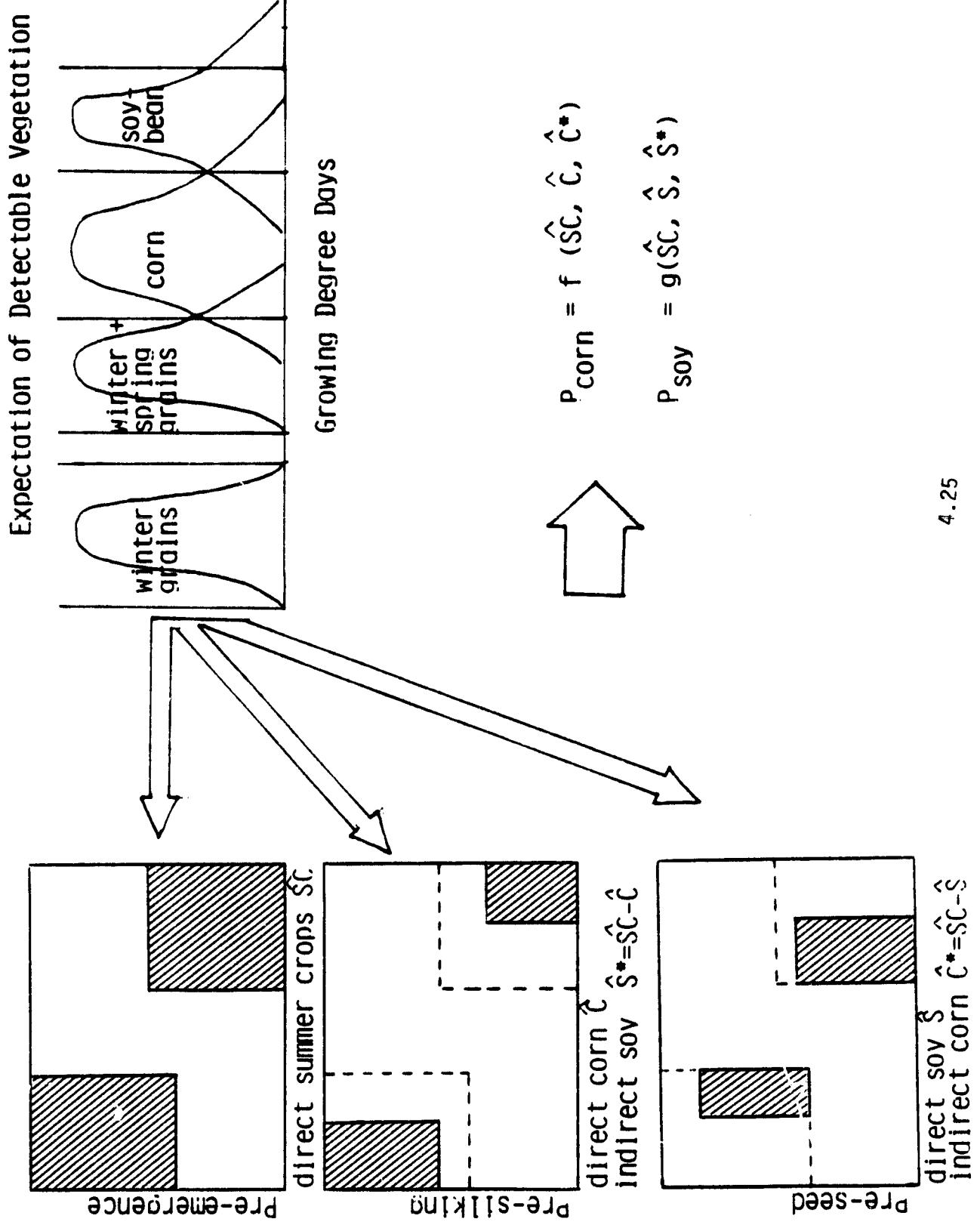
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### C/S-4 BAHDMAR/MAGNUS PROCEDURE

LEVEL	TYPE	REGION	CROP PROC.	NO.	VAR.	PROCEDURE NAME	DATE
SUBSYSTEM	AREA ESTIMATION	CODE	U. S. CORN BELT	C/S		PROFILE PARAMETER CLASSIFICATION	PROPORTION EST. CLASSIFICATION
ANALYSIS / CROP CALENDAR & DATA PREP.	LABELING TARGETS IDENT. & PARAMETER ESTIMATION						• SPECTRAL AIDS PROGRAM



COLOR SEQUENCE BASED METHODS  
MC-2



## COMPARISON OF AREA ESTIMATION PROCEDURES

<u>PROCEDURE NAME</u>	<u>C/S-1</u>	<u>C/S-1A</u>	<u>MC-2</u>	<u>CS-4</u>	<u>CS-2A</u>	<u>CS-5</u>
DEVELOPER	ERIM/UCB	ERIM/UCB/LEMSCO	LEMSCO	JSC/LEMSCO	JSC/LEMSCO/ERIM	ERIM/UCB
CROP CALENDAR	HISTORIC	HISTORIC	MODEL	MODEL	HISTORIC	OPTIONAL
PREPROCESSING	EXTERNAL EFFECTS	EXTERNAL EFFECTS	GREY LEVEL	SUN ANGLE	OPTIONAL	EXTERNAL EFFECTS
FEATURE EXTRACTION	TASSELED CAP GRABS	TASSELED CAP, GRABS	Spatial COLOR PROFILE SEQUENCE	Spatial COLOR PROFILE PARAMS $\alpha, \beta, \sigma$	TASSELED CAP GRABS	TASSELED CAP
LABELING TARGET	QUASI-FIELDS	QUASI-FIELDS	BIN	SUPER PURF DOT	RELOCATED DOT	OPTIONAL
LABELING METHOD	ANALYST DECISION TREE	ANALYST/MACHINE DECISION TREE	AUTOMATIC HISTORICAL COLOR SEQUENCE	ANALYST/MACHINE PROFILE FILE FEATURE THRESHOLDS	AUTOMATIC DECISION TREE	SIGNATURE PROFILE MATCHING
ESTIMATION METHOD	STRATIFIED AREA ESTIMATE (S.A.E.)	BIAS CORRECTED S.A.E.	BIAS CORRECTED AGGREGATION	LINEAR DECISION RULE	RELATIVE COUNT	IN DEVELOPMENT
EFFICIENCY	MANUAL	SEMI-AUTOMATIC	AUTOMATIC	SEMI-AUTOMATIC	SEMI-AUTOMATIC	AUTOMATIC
TIMELINESS	POST TASSELING	POST TASSELING	PRE-SEED	POST TASSELING	POST TASSELING	THROUGH SEASON
AREA OF APPLICATION	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	ARGENTINA FSRs
CROPS	C,S	C,S	C,S	C,S	C,S	C,S
AVAILABILITY	U.S. PILOT	U.S. PILOT / ARG EXPLORATORY	U.S. PILOT	U.S. PILOT	U.S. PILOT	ARG EXPLORATORY

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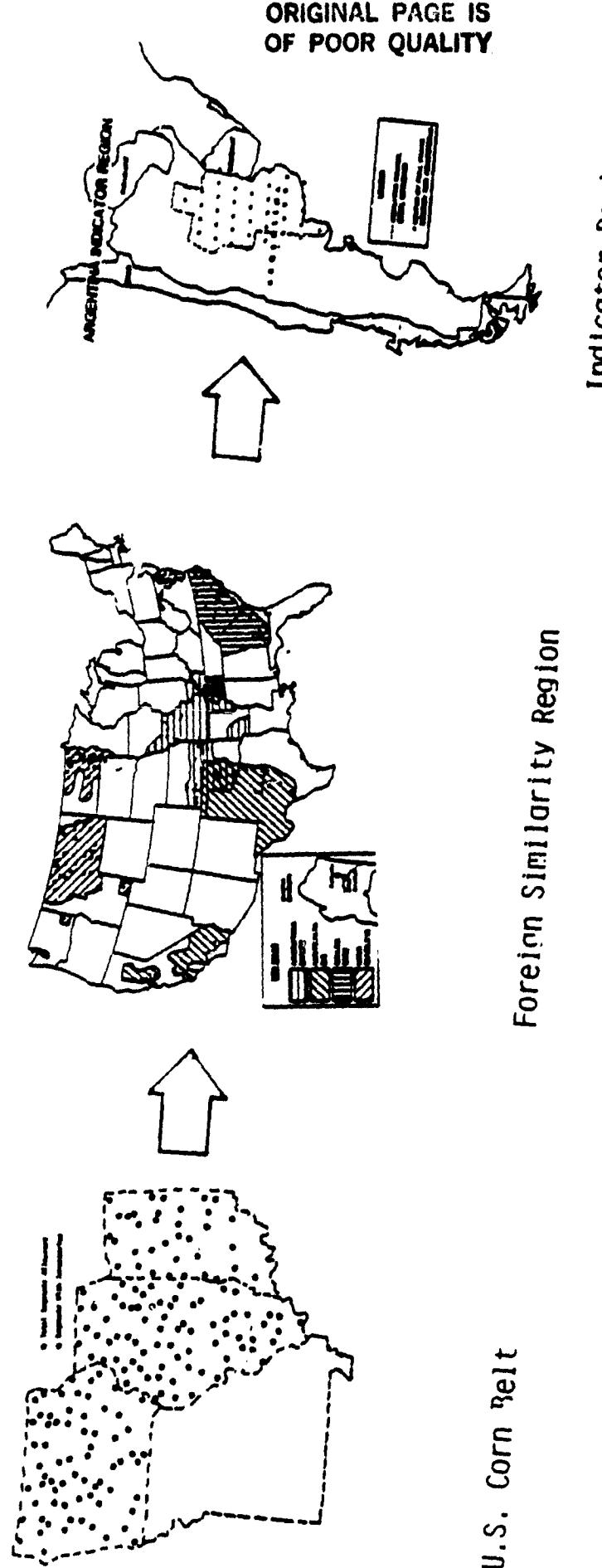
**ROLE OF THE PILOT EXPERIMENT IN  
FOREIGN TECHNOLOGY DEVELOPMENT**

R. CICONE  
9/29/81

## **PROGRAM OBJECTIVES**

- Develop Techniques Using Landsat MSS for Corn and Soybean Inventory in Argentina
- Examine Feasibility of Technology Application to Corn and Soybeans in Brazil
- Evaluate Crop Inventory Technology on the Basis of Efficiency, Objectivity, Timeliness and Accuracy
- Examine Feasibility and Incremental Gain in Augmenting the Crop Inventory Technology with Thematic Mapper Technology

TECHNICAL GROWTH THROUGH STAGED DEVELOPMENT AND EVALUATION



**PROGRAM GOALS**

	81	82	83	84	85
Design, Development, Integration	U.S. based technology development	Argentina technology development	Argentina technology development	Argentina technology integration	TM technology development
Experiments	U.S. C/S Pilot	Argentina Exploratory Experiment	Brazil feasibility study	Argentina Pilot Experiment	

**TECHNICAL GOALS OF EXPERIMENTS**

Target Area	FY82	FY83	FY84	FY85
Target Crops	U.S. Corn Belt	Argentina Indicator Region	Argentina/Brazil Indicator Regions	Argentina/Brazil Indicator Regions
Technique	Corn, Soybeans	Corn, Soybeans, Confusion Crops	Corn, Soybeans, Confusion Crops	Corn, Soybeans, Confusion Crops
Timeliness	Semi-Automatic	Automatic	Automatic	Automatic
Information Content	At-harvest	Mid-season to Harvest	Early Season to Harvest	Early Season to Harvest
	Crop Acreage	Crop Acreage	Crop Acreage	Crop Production

## TECHNICAL BENEFITS OF CORN BELT BASED PILOT EXPERIMENT

- Provides Controlled Environment for the Analysis of Corn and Soybeans
  - Ideal farm management conditions
  - Absence of confusion crops
  - Extensive knowledge of growing conditions and crop calendars
  - Thorough understanding of corn and soybeans phenological and spectral behavior under 'best case' conditions
- Addresses Key Technical Needs for a New Crop Application
  - Landsat based multicrop acreage estimation
  - Impact of field size and mixed pixels
- Evaluates Subsystem and Key Subcomponent Methods Applicable to Foreign Regions
  - Acreage estimation, aggregation
  - Crop calendar utilization
  - Target definition
  - Objective labeling
- Provides a Foundation of Well-Understood Technology That can be Enhanced and Adapted to Foreign Applications

R. RIZZELL  
9/29/81

5.0

## **5.0 SUMMARY AND OUTLOOK**

## SUMMARY OF FY81 ACCOMPLISHMENTS

- 0 DEVELOPMENT AND IMPLEMENTATION OF AN EXPERIMENTAL METHODOLOGY WHICH SUPPORTS ADVANCEMENT OF CORN AND SOYBEANS TECHNOLOGY HAS BEEN ACCOMPLISHED.
  - + STARS - EXPERIMENTAL AND DEVELOPMENTAL ENVIRONMENT
  - + FCPF CONFIGURATION - SEGMENT PROCESSING AND ACCURACY ASSESSMENT
- 0 CONDUCTED PILOT EXPERIMENT TO EVALUATE BASELINE TECHNOLOGY AND IDENTIFY CRITICAL SUBCOMPONENT ERROR SOURCES.
  - + ACCURATE SUMMER CROP ESTIMATES ARE SUBSTANTIAL IMPROVEMENT OVER PREVIOUS TECHNOLOGY (PVT)
  - + THREE-CROP ESTIMATES COMPARABLE TO PVT TECHNOLOGY WITH IMPROVED PRECISION, HOWEVER SIGNIFICANT BIAS REMAINS.
  - + EXPECTED PROCESSABILITY OF 75% INDICATED FOR TWO-CROP ESTIMATES AND 63% FOR THREE-CROP ESTIMATES IN CENTRAL CORN BELT FOR 1990.
  - + VARIABILITY OBSERVED BETWEEN ANALYST TEAMS INDICATES NEED FOR FURTHER OBJECTIVITY.
  - + HIGH THROUGHPUT REQUIREMENT POINTS TO NEED FOR GREATER EFFICIENCY.
  - + IDENTIFIED SUBCOMPONENT CONTRIBUTORS TO ERROR AND RANKED THE MAGNITUDE OF THEIR IMPACT.
    - TARGET DEFINITION STILL A SIGNIFICANT PROBLEM
    - TREATMENT OF MIXED PIXELS NOT COMPLETELY RESOLVED
    - LABELING OF ANOMALOUS SIGNATURES AND MIXED BLOBS INACCURATE

- 0 MODIFIED THE BASELINE BASED ON EARLY PILOT DETECTION OF SUBCOMPONENT DEFICIENCIES ADDRESSING ACCURACY, EFFICIENCY, AND OBJECTIVITY.
  - + MACHINE ERRORS - UNSAMPLED STRATUM, TARGET DEFINITION
  - + LABELING ERRORS - SEMI-AUTOMATION, ANOMALOUS SIGNATURES
  - + SUBCOMPONENT AUTOMATION
- 0 DEVELOPMENT OF THE C/S TECHNOLOGY FOR FOREIGN APPLICATION IS IN PROGRESS.
  - + FOREIGN SIMILARITY REGIONS (FSR'S) AND INDICATOR REGIONS (IR'S) HAVE BEEN SELECTED, SAMPLED, AND SEGMENT BASED MSS DATA ACQUISITION UNDERWAY.
  - + SAMPLING FRAME HAS BEEN DEVELOPED BY USDA FOR BRAZIL AND ARGENTINA IS NEAR COMPLETION.
  - + SIXTEEN SEGMENTS OF GROUND TRUTH FROM ARGENTINA ARE PREPARED.
  - + A BASE OF AGRONOMIC DATA AND UNDERSTANDING OF ARGENTINA FARM MANAGEMENT AND ENVIRONMENTAL CONDITIONS IS UNDER DEVELOPMENT.
  - + A STUDY OF KEY CONFUSION CROPS, THEIR SPECTRAL AND PHENOLOGICAL BEHAVIOR, USING U.S. DEVELOPMENTAL SITES IN FOREIGN SIMILARITY REGIONS, IS UNDERWAY.
  - + DEVELOPMENT IN EARLY AREA ESTIMATION USING PROFILE MATCHING TECHNIQUES HAS BEEN INITIATED.

## OUTLOOK

- 0 THE CORN AND SOYBEANS PILOT HAS ACCOMPLISHED WHAT WAS INTENDED FOR THE YEAR PLUS---
  - + GOOD INITIAL UNDERSTANDING OF THE TECHNOLOGY NEEDS FOR IMPROVING BOTH PERFORMANCE AND EFFICIENCY.
- 0 THE END-TO-END CONFIGURATION AND EVALUATION ARE NEEDED.
  - + PLANNED 1-STATE DEMONSTRATION SHOULD PROVIDE THIS.
- 0 MAJOR EMPHASIS WILL BE PLACED ON THE DEVELOPMENT AND EVALUATION OF TECHNOLOGY TO BE CARRIED TO FOREIGN APPLICATIONS.